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STAFF REPORT

Reserved Water Rights Compact Commission

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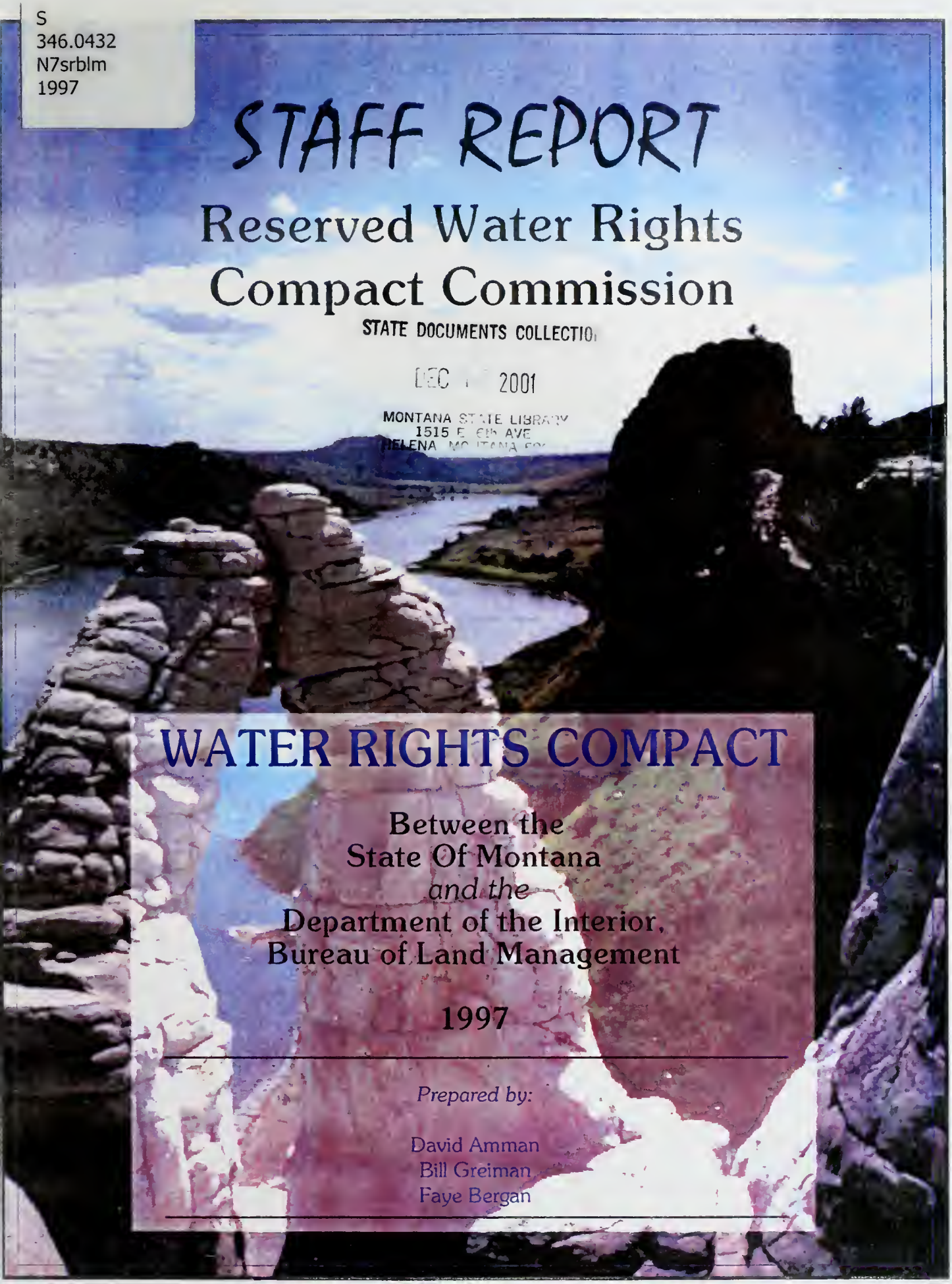

WATER RIGHTS COMPACT

Between the
State Of Montana
and the
Department of the Interior,
Bureau of Land Management

1997

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WATER RIGHTS COMPACT

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STATE OF MONTANA

AND THE

DEPARTMENT OF THE INTERIOR, BUREAU OF LAND MANAGEMENT

1997

RESERVED WATER RIGHTS COMPACT COMMISSION STAFF
December, 1997

TABLE OF CONTENTS

INTRODUCTION 1
Background of the Montana Reserved Water Rights Compact Commission 1
Background of Negotiations with the Bureau of Land Management 2

PROVISIONS OF THE WATER RIGHTS COMPACT BETWEEN THE STATE OF MONTANA AND THE DEPARTMENT OF THE INTERIOR, BUREAU OF LAND MANAGEMENT 6

RECITALS 6

ARTICLE I: DEFINITIONS 6

ARTICLE II: WATER RIGHT 6

INSTREAM FLOW FOR THE UPPER MISSOURI NATIONAL WILD AND SCENIC RIVER 7

Legal/Historical Background of the Upper Missouri National Wild and Scenic River/Priority Date 7
Reverse Approach 10

INSTREAM FLOW FOR THE BEAR TRAP CANYON PUBLIC RECREATION SITE 12

Legal/Historical Background of the Bear Trap Canyon Public Recreation Site/Priority Date 12

ARTICLE III: UMNW&SR WATER RIGHT IMPLEMENTATION 13

Available Water Supply 13
Method for Calculation of Monthly Depletions Subtracted from or Added to the Available Water Supply 14
Uses Not Subtracted from the Available Water Supply 15
Administration and Enforcement 16

ARTICLE IV: BTCPRS WATER RIGHT IMPLEMENTATION 17

ARTICLE V: GENERAL PROVISIONS 17

ARTICLE VI: FINALITY OF COMPACT 17

APPENDICES TO THE COMPACT 18

APPENDICES TO THE STAFF REPORT 18

INTRODUCTION

Background of the Montana Reserved Water Rights Compact Commission

The Montana Reserved Water Rights Compact Commission (Commission) was established by the Montana Legislature in 1979,[1] to help integrate reserved water rights into the state adjudication process. The Commission is composed of nine members. Four members are appointed by the Governor, two members are appointed by the President of the Montana Senate, two members are appointed by the Speaker of the Montana House of Representatives, and one member is appointed by the Montana Attorney General. Members serve 4 year terms.

The Commission is authorized to negotiate settlements with federal agencies and Indian tribes claiming federal reserved water rights within Montana.[2] A federal reserved water right is a right to use water that is expressly or implicitly created by an act of Congress, a treaty, or an executive order establishing a tribal or federal reservation. It is a right that is recognized by federal law and need not be pursued through the standard state process for appropriation of water. The amount of water to which a reservation is entitled depends on the purpose for which the land was reserved. The water right does not require beneficial use as defined by State law and may not be lost through abandonment.

In Montana, reserved water rights have been claimed for seven Indian reservations, including the Blackfeet, Rocky Boy's, Fort Belknap, Fort Peck, Flathead, Crow, Northern Cheyenne, and for allotments for the Turtle Mountain Chippewa Tribe. Federal agencies claiming reserved water rights include the Bureau of Land Management, the National Park Service, the U.S. Forest Service, and the U.S. Fish and Wildlife Service.

Legal and historical research and technical analyses are prepared for the Commission by an eleven member staff, including a program manager, two attorneys, an agricultural engineer, a historical researcher, two hydrologists, a soils scientist, a geographic information specialist, and administrative staff.

Since its inception in 1979, the Commission has negotiated compacts with the Assiniboine and Sioux Tribes of the Fort Peck Reservation, the Northern Cheyenne Tribe, the National Park Service, the Bureau of Land Management, the U.S. Fish and Wildlife Service, and the Chippewa Cree Tribe of the Rocky Boy's Reservation. As required by Montana law, all five compacts have been approved by the

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[1] Mont. Code Ann. § 2-15-213(1).

[2] Mont. Code Ann. § 2-15-701.

Montana legislature. To date, only the Northern Cheyenne Compact has been entered in a decree by the Water Court.

Background of Negotiations with the Bureau of Land Management

The Montana Water Use Act, Title 85, chapter 2, MCA, passed in 1973 and amended by Senate Bill 76 in 1979, established a state-wide general adjudication for all state-based water rights in existence before July 1, 1973, and all federal and Indian reserved water rights. Federal reserved water rights with a priority date of July 1, 1973, or later are also subject to the same process and adjudication as a federal reserved water right with a priority before July 1, 1973. [3] The Commission is authorized to negotiate settlement of federal reserved water rights with a priority date of July 1, 1973, or later. [4]

Discussions concerning possible settlement negotiations between the State and the Bureau of Land Management (BLM) began during the early 1980s for federal reserved water rights for the Upper Missouri National Wild and Scenic River. In 1984, the BLM submitted a Proposal to the Commission for quantification of federal reserved water rights for instream flow for the Upper Missouri National Wild and Scenic River. [5] The reserved water right claims for instream flow in the 1984 Proposal were based on studies done by the BLM and the Montana Department of Fish, Wildlife, and Parks to describe flows for fish and aquatic invertebrate species and goose nesting. [6] The BLM conducted studies to support the proposed recreational boating flows, and also researched literature to claim flows to maintain channel stability. [7]

The proposed flows varied by time of year and were proposed for three separate stretches of the Wild and Scenic measured at Fort Benton, Virgelle, and Landusky (Fred Robinson Bridge). [8]

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[3] Mont. Code Ann. § 85-2-228(1).

[4] Mont. Code Ann. § 85-2-228(3).

[5] Instream Flow Requirements for the Wild and Scenic Missouri River, U.S. Department of the Interior, Bureau of Land Management, Montana State Office (1984). (Appendix A.)

[6] Instream Flow Studies Determinations, Id. at 3.

[7] Id. at 4-5.

[8] Id. at 22.

Three negotiating sessions held in 1985 and 1986, were essentially informational and no commitments or responses were made by the State, [9] except that the Commission decided to negotiate with the BLM on the basis of a reserved water right for the Upper Missouri National Wild & Scenic River. [10] However, neither the scope of the reserved water right or the quantity was not discussed at this time.[11]

At a Commission Negotiating Team Meeting on July 28, 1988, several issues were identified and the Commission felt that additional information would be necessary to evaluate these issues. Negotiations with the BLM slowed while the Commission awaited additional information from a water modeling effort that would simulate existing uses of water in the upper Missouri River basin and examine the effects of additional consumptive development. [12] Completion of the state water reservation process for the upper Missouri River basin would provide better projections for future development.[13] Concern had also been raised whether the Commission should negotiate federal reserved water rights with a priority date on or after July 1, 1973.[14]

In 1991, the Legislature passed H.B. 361 specifically subjecting all federal reserved water rights with a priority date of July 1, 1973, or later to the same process and adjudication as those with a priority date before July 1, 1973. [15] The Bill also clarified the Legislature's intent that settlement of federal reserved water rights with a priority date of July 1, 1973, or later may be negotiated by the Commission.[16]

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[9] November 13, 1985; March 12, 1986; and April 10, 1986.

[10] Letter to Richard K. Aldrich, from W. Gordon McOmber, September 24, 1985.

[11] See, Memorandum to Commission Members, Marcia Rundle, Reserved Water Rights Created by the National Wild and Scenic Rivers Act, 82 Stat. 906, 16 U.S.C. §§ 1271-1287 (1976)(August 26, 1985), p. 2.

[12] Letter to Marvin LeNoue, from Gene Etchart, December 5, 1988.

[13] Summary of the BLM Negotiating Team Meeting, July 28,1988, p. 6 (statement by Larry Fasbender, DNRC Director); Mont. Code Ann. §§ 85-2-316 and 331(1)(a).

[14] Memorandum, to Reserved Water Rights Compact Commission, from Peter T. Stanley, Negotiation of Water Claims Accruing after July 1, 1973 (August 9, 1984).

[15] Chapter No. 343, Montana Session Laws 1991, p. 829 (H.B. 361), Mont. Code Ann. § 85-2-228.

[16] Mont. Code Ann. § 85-2-228(3).

The Board of Natural Resources and Conservation issued a Final Order Establishing [State] Water Reservations above Fort Peck Dam on June 30,1992. Studies done as part of the state reservation process included identification of irrigable lands and future municipal needs in the upper Missouri River basin, [17] and a Missouri River Water Availability Model. [18] The Missouri River Water Availability Model was originally developed by the Department of Natural Resources and Conservation (DNRC), in cooperation with the Bureau of Reclamation and Montana Power Company. The model was further refined by the Bureau of Reclamation, in cooperation with DNRC and Montana Power Company, using the Bureau of Reclamation Hydrologic River Operations Study (HYDROSS) model. [19] A more complete description of the model is part of the Joint Technical Working Group Report. (Appendix C.)

On August 24, 1992, the BLM wrote the Commission requesting that negotiations resume.[20] Active negotiations between the State and the BLM began in July, 1993. The BLM amended the 1984 Proposal for the Upper Missouri National Wild and Scenic River to include consecutive days for channel maintenance flow, and flows of 50,000 cfs at Fort Benton one year out of nine to maintain the riparian cottonwood community through the River corridor.[21]

In May, 1994, the BLM also submitted a Proposal for Bear Trap Canyon Public Recreation Site for recognition of a reserved water right for public recreational use. The flow claimed by the BLM as a reserved water right was 1,100 cfs, year round.[22]

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[17] Methodology Manual For Conservation District Water Reservation Applications, December, 1991 (Appendix B); Draft Environmental Impact Statement for Water Reservation Applications above Fort Peck Dam, June, 1991.

[18] Draft Environmental Impact Statement for Water Reservation Applications above Fort Peck Dam, June, 1991, Appendix C.

[19] Upper Missouri River Water Availability Study Hydrology Model Development, Bureau of Reclamation (February 2, 1994).

[20] Letter to Joan Specking, from John A. Kwiatkowski, August 24, 1992.

[21] Letter to Dave Wanzenried, from John Thompson, Acting Deputy State Director, BLM, December 16, 1993; A Research Proposal in Support of Flow Recommendations for Maintaining and Enhancing Riparian Habitat along the Missouri River in Montana between Canyon Ferry Dam and Fort Peck Reservoir, National Ecology Research Center, U.S. Fish and Wildlife Service (Sept. 30, 1992).

[22] Assertion of Federal Reserved Water Right for Instream Flow in the Bear Trap Canyon of the Madison River, U.S. Department of Interior, Bureau of Land Management (May, 1994) (Appendix D.)

The negotiations with the BLM took over three years of active negotiations. Most of the negotiation and technical work involved the claims for the Upper Missouri National Wild and Scenic River. This Missouri River stretch drains a very large basin with many complex water issues. The parties had major disagreements as to the scope of reserved water rights authorized by Congress. The specifics of the legal basis for the BLM's claims and the history of how the parties reached agreement will be addressed in the sections of this Report dealing with quantification and implementation of reserved water rights recognized in the Compact.

Members of the Commission Negotiating Team for the BLM negotiations were: Senator Chuck Swysgood, Chair of the Negotiating Team; Chris Tweeten, Chair of the Commission; former Senator Jeff Weldon; and Tara Depuy. Senator Lorents Grosfield and former Representatives Bob Gilbert and Dave Wanzenreid also served on the Commission Negotiating Team during active negotiations. Commission staff working on the Compact included David Amman, Hydrologist and Technical Team Leader; Faye Bergan, Legal Counsel; Craig Bacino, Geographer and GIS Specialist; Susan Cottingham, Staff Director; and Bill Greiman, Agricultural Engineer.

Negotiators for the BLM Federal Negotiating Team during active negotiations were: John Kwiatkowski, Deputy State Director, BLM, Billings; Tim Bozorth, State Hydrologist, BLM, Billings; Richard Aldrich, Field Solicitor for the Department of the Interior, Billings; John Chaffin, Solicitor's Office, Department of the Interior, Billings; and Jim Dubois, U.S. Department of Justice, Denver, Colorado. The Federal Team also relied on participation by the U.S. Fish and Wildlife Service and the Bureau of Reclamation.

Ten negotiating sessions were held from 1993-1996 located in either Billings, Helena, Bozeman or Fort Benton. Negotiating sessions are open to the public and public comment was received during meetings. A series of informational meetings were held in Dillon and Three Forks (May 31, 1994) and Great Falls, Shelby and Choteau (June 9, 1994). After agreement in principal was reached and a draft Compact written, public hearings were held in Dillon (December 5, 1996), Ennis and Bozeman (December 9, 1996), Lewistown (December 10, 1996), Helena (December 11, 1996), Great Falls, Conrad and Fort Benton (December 16, 1996).

The proposed Compact received approval from the full Commission on December 18, 1996. The Compact was ratified by the 1997 Legislature and was signed by Governor Marc Racicot on March 27, 1997. The Compact became effective on September 10, 1997 when signed by Governor Marc Racicot, Bob Armstrong, U.S. Department of the Interior, and Peter Coppelman, U.S. Department of Justice.

PROVISIONS OF THE WATER RIGHTS COMPACT BETWEEN THE STATE OF MONTANA AND THE DEPARTMENT OF THE INTERIOR, BUREAU OF LAND MANAGEMENT

This Report will describe all the major provisions of the Compact, history of how the agreement was reached, and the legal and technical basis for Commission decisions in negotiating the Compact. A Joint Technical Staff Report describing the specifics of how joint technical staff recommendations made to both negotiating teams were arrived at is attached as Appendix C and referred to often in this Report.

RECITALS

The "Recitals" listed at the beginning of the Compact cite the authority of the compacting parties to enter into the settlement agreement. The authority for the Reserved Water Rights Compact Commission to negotiate settlement of claims by the federal government to non-Indian reserved water rights within the State of Montana, including those with a priority date on or after July 1, 1973, is set out in Mont. Code. Ann. §§ 85-2-703 and 85-2-228(3). Since the Reserved Water Rights Compact Commission was created as part of the Montana state-wide water adjudication and the compacting process is an integral part of the adjudication, all settlements of reserved water rights are in settlement of litigation (quantification and settlement of claims that would have otherwise been filed with the Water Court). The U.S. Department of Justice has the authority to settle litigation on behalf of the United States and is, therefore, a member of the Federal Negotiating Team and a signator to this Compact. Authority for the Department of the Interior is contained in 43 U.S.C § 1457.

ARTICLE I - DEFINITIONS

Article I of the Compact contains definitions. Specific definitions will be discussed in other sections of this Report, if relevant.

ARTICLE II - WATER RIGHT

The Compact describes and quantifies water rights that are the full and final settlement of the reserved water right claims for the Upper Missouri National Wild and Scenic River (UMNW&SR) and the Bear Trap Canyon Public Recreation Site (BTCPRS). The water rights for both the UMNW&SR and the BTCPRS are for instream flows only. No consumptive water rights are recognized under this Compact. The water rights for each of these two units is described separately.

INSTREAM FLOW FOR THE UPPER MISSOURI NATIONAL WILD AND SCENIC RIVER

Legal/Historical Background of the Upper Missouri National Wild and Scenic River/ Priority Date

The Upper Missouri National Wild and Scenic River is a 149-mile stretch of the Missouri River corridor from Fort Benton downstream to Fred Robinson Bridge in north-central Montana. (Appendix E - Map). This is the last major undammed portion of the Missouri River. The River corridor has many unique features, including the impressive "white cliffs" of the Missouri. The Missouri River stretch that is part of the Wild and Scenic River System was extensively recorded in the Journals of Lewis and Clark in 1805. This area is very remote and the landscape is unblemished. The area is commonly referred to as the "Missouri Breaks."

The land area above the UMNW&SR encompasses about of 1/4 of the State - approximately 41,000 square miles.

In 1963, a joint study of the Missouri River was done by the Secretaries of the Interior and Army to re-assess hydropower development. [23] Two dams, one at Fort Benton and the other at Cow Creek, were the most feasible. A high dam at Cow Creek would impact a significant portion of the Missouri Breaks.[24]

During this time, attempts to preserve this stretch of the Missouri River began. In 1960, the National Park Service examined the River and recommended creation of the Lewis and Clark National Wilderness Waterway as a unit of the National Park System.[25] During the mid-1960s, the Bureau of Outdoor Recreation studied this segment of the Missouri River and recommended it be protected as the Missouri Breaks National River. [26]

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[23] Corps of Engineers and Department of Interior, Missouri River, Fort Peck Reservoir to Vicinity of Fort Benton, Montana - Joint Report on Water and Land Related Land Resources Development (June, 1963)(Appendix II, S. 1506, Hearings before the Subcomm. on the Environment and Land Resources of the Senate Comm. on Interior and Insular Affairs, Washington, D.C., September 19, 1975.)

[24] Id. at 2 and 6.

[25] Id. at 2.

[26] Department of Interior, Bureau of Outdoor Recreation, The Middle Missouri: A Rediscovery (1966).

Eight rivers were designated as the original components of the Wild and Scenic River System when the Wild & Scenic Rivers Act was passed in 1968. The Missouri Breaks was not one of these originally designated river segments, but a 180 mile stretch between Fort Benton and Ryan Island was included in the 1968 Act as one of the rivers to undergo study for possible addition to the System. [27]

In the early 1970s, several unsuccessful measures were introduced to protect the area. In 1970, Congressman Saylor (PA) introduced a bill to establish the Missouri Breaks Scenic River (H.R. 17233) which was defeated. In 1971, Senator Metcalf introduced a bill to establish the Missouri Breaks Scenic Recreation River (S. 1405) but no action was taken. In 1973, Senator Metcalf re-introduced the bill (S. 1009) again with no action. In Montana an attempt was made at a state designation for protection of the River. H.B. 133 introduced in the 1973 legislative session would have created a state version of the wild and scenic river system with the Missouri Breaks being a component part. This effort was also unsuccessful.

In 1975, Senator Metcalf introduced S. 1506 to designate the Missouri Breaks as part of the Wild and Scenic River System. This was "a modified bill which took into account increased protection of agricultural interests found along the river." [28] A similar bill (H.R. 15422) was carried in the House by Representative Melcher. Subsequently, H.R. 15422 was tabled when Melcher introduced amendments to S. 1506 to incorporate the language of H.R. 15422 (the amendments involved use of lands within the corridor, access to irrigation water, management of the area, and a bridge at Winifred). These amendments were supported by Metcalf. The Senate concurred with House amendments and passed S. 1506 in September, 1976. President Ford signed the legislation on October 12, 1976.[29]

The specific legislation involved here is titled the Missouri Breaks Freeflowing River, Pub.L. 94-486 (Oct. 12, 1976), 16 U.S.C § 1274. (Appendix F.) Unlike many of the reserved water right claims there is a significant amount of relatively recent legislative history concerning this legislation. The legislative history makes it clear that the River is to remain freeflowing (minor diversions would be allowed but not impoundments). The testimony focuses on the historic, scenic and recreational significance of this stretch of the Missouri River.

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[27] 16 U.S.C. § 1276.

[28] Bureau of Land Management, Final Upper Missouri Wild and Scenic River Management Plan 7 (1978).

[29] October 12, 1976 was the priority date claimed by BLM. 90 Stat. 2327.

The BLM claimed reserved water rights for the UMNW&SR for the following instream flow uses:

- Fish and Aquatic Habitat
- Goose Nesting
- Recreation
- Channel Stability
- Riparian Cottonwood Community

The BLM cited the legal basis for claiming reserved water to protect these "values" as the Wild & Scenic Rivers Act.[30]

The Wild and Scenic Rivers Act of 1968, 16 U.S.C. § 1271, states:

> It is hereby declared to be the policy of the United States that certain selected rivers of the Nation which, with their immediate environments, **possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations.** The Congress declares that the established national policy of dam and other construction at appropriate sections of the rivers of the United States needs to be complemented by a policy that would preserve other selected rivers or sections thereof in their free-flowing condition to protect the quality of such rivers and to fulfill other vital national conservation purposes. (Emphasis added.)

The Wild and Scenic Rivers Act is unique because it discusses reserved water rights (although phrased as a negative).

> Designation of any stream or portion thereof as a national wild, scenic or recreational area shall not be construed as a reservation of the waters of such streams for purposes other than those specified in this chapter, or in quantities greater than necessary to accomplish those purposes.[31]

The BLM asserted that the Wild and Scenic Rivers Act expressly created a reserved water right for the UMNW&SR.

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[30] 16 U.S.C. § 1271, et seq.

[31] 16 U.S.C. § 1284(c).

The Commission acknowledged (for negotiation purposes) that the Wild and Scenic Rivers Act could serve as the underlying legislation authorizing creation of a reserved water right. However, the Commission asserted that examination of the documents reserving the area from the public domain was necessary to determine the "precise federal purposes," and thus, the existence, nature and scope of a reserved water right.[32]

Pub.L. 94-486, which designates the UMNW&SR as a component of the Wild and Scenic River System, is a very detailed piece of legislation when compared to most Wild and Scenic River designations. A specific discussion of reserved water rights is set out in the Senate Report for S. 1506.

> **The designation of the Missouri Breaks is not a reservation of its waters for purposes other than to preserve the river in a free-flowing state**. The State's jurisdiction over waters of any river is not affected by the Wild and Scenic River Act. The Act does not alter established principles of existing water law. The waters above or below a wild and scenic river are not affected as long as such water projects do not invade or significantly detract from the scenic status of the designated river segment.[33]

Based on review of the statutory language designating the UMNW&SR and its legislative history, the Commission did not agree with the nature and scope of the reserved water right claimed by the BLM for the UMNW&SR.

Reverse Approach

The parties did not agree on the reservation purposes for the UMNW&SR and the quantity of water necessary to accomplish those purposes. However, the parties could agree that, in designating the UMNW&SR, Congress had intended that there was to be

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[32] Solicitor's Opinion #M-36914, 86 I.D. 553, 608 (1979)("[T]he scope of the reserved water right . . . is to be resolved examining the purposes of the [Wild and Scenic Rivers] Act, limited by protecting those features which led to a particular river's designation."); United States v. New Mexico, 438 U.S. at 703; State ex. rel. Greely v. Confederated Salish and Kootenai Tribes, 219 Mont. 76, 98 (1987)(citing, United States v. City and County of Denver, 656 P.2d 1, 20 (Colo. 1983)).

[33] *Senate Comm. on Interior and Insular Affairs*, S. Rep. No. 502, 94th Cong., 1st Sess. at 9. (Emphasis added.) Under the Wild and Scenic Rivers Act "free-flowing" means "existing or flowing in natural condition without impoundment, diversion, straightening, rip-rapping, or other modification of the waterway. The existence, however, of low dams, diversion works, and other minor structures at the time any river is proposed for inclusion in the national wild and scenic rivers system shall not automatically bar its consideration for such inclusion: Provided, That this shall not be construed to authorize, intend, or encourage future construction of such structures within components of the national wild and scenic rivers system." 16 U.S.C. § 1286(b).

some "maintenance of flow" as part of "free-flowing" and that Congress had recognized that water for future agricultural use would not interfere with "maintenance of flow."[34]

The parties began exploring what we have come to refer to as the "reverse approach." In this case, existing and future water use under state law is specified and whatever remains in the river is recognized as the reserved water right.

The reverse approach was feasible for the BLM's reserved water right for the UMNW&SR for several reasons. The mainstem Missouri River has a flow record that goes back almost 100 years. As previously discussed, these flows have been modeled on a monthly basis. Therefore, the BLM was willing to recognize that existing water rights from the UMNW&SR priority date of October 12, 1976 through December 31, 1987, the ending period of the model, were reflected in the historic flows. The BLM reserves the right to object to water use claims in the Water Court to ensure that water rights decreed reflect historic use patterns.

For future water use, the State had to predict reasonable water needs in the upper Missouri River basin. The BLM was willing to recognize some level of future water use as long as the quantity was based on reasonable assumptions and the impacts to streamflows in the UMNW&SR were not severe. The state water reservation process for the upper Missouri River basin had recently been completed.[35] That process resulted in very good information on future State water needs. A Working Group of Commission and DNRC staff was formed to estimate and quantify a volume of water for future use. The Group estimated future additional agricultural development (100,000 acres), and future increased municipal and industrial demands (24,000 acre feet per year) in the upper Missouri River basin. A more complete description of the Working Group and its findings is part of the Joint Technical Working Group Report. (Appendix C.)

The Commission originally proposed an aggregate block of water for future use. The BLM rejected this idea because they could not evaluate the effect of future uses on monthly flows at the UMNW&SR. The parties agreed to look at future water needs on a monthly basis.

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[34] Testimony of Rep. Melcher, *Hearings Before the Subcomm. on National Parks and Recreation of the House Comm. on Interior and Insular Affairs*, at 10, 11 and 17 (June 21,1976, Washington, D.C.).

[35] Board of Natural Resources and Conservation, Final Order Establishing [State] Water Reservations above Fort Peck Dam, June 30,1992.

The BLM adjusted their proposal by averaging the instream flow claims on a monthly basis. This allowed the parties to use the model to compare future water use under different development scenarios with the remaining flow at the Fred Robinson Bridge.[36]

At this point, the negotiators needed detailed information on how much water would be necessary to meet future water needs on a monthly basis, how depletions would be calculated and administered, and what types of water uses would be counted against the future use limits. A Joint Technical Working Group was formed with technical staff members from BLM, Commission, and DNRC. The Joint Technical Working Group prepared a report for the negotiating teams, which became the cornerstone of the agreement for the UMNW&SR. (Appendix C.)

Using the Joint Technical Working Group Report as a base, the negotiating teams were able to reach an agreement using the reverse approach that allows for future state development and protects the values of the UMNW&SR. The instream flow water right for the UMNW&SR is in the amount of the remaining flow of the Missouri River at Fred Robinson Bridge after (1) all water appropriations completed before December 31, 1987; (2) the volumes of water designated for the Available Water Supply (described in Article III); and (3) uses not subtracted from the Available Water Supply (described in Article III). The priority date is October 12, 1976.

INSTREAM FLOW FOR THE BEAR TRAP CANYON PUBLIC RECREATION SITE

Legal/Historical Background of the Bear Trap Canyon Public Recreation Site/ Priority Date

The Bear Trap Canyon Public Recreation Site is located on the Madison River directly below the Madison Dam (Ennis Lake). The BTCPRS is approximately 9 miles long and is part of the Lee Metcalf Wilderness Area. The Bear Trap Canyon is a popular white-water recreation destination and is also heavily used by fishermen and hikers.

The BTCPRS was withdrawn and reserved by Secretary of the Interior Public Land Order 5062 (Montana 17093), published in the Federal Register on June 9, 1971, pursuant to authority granted by Executive Order No. 10355 of May 26, 1952. The purpose of the reservation is for public recreation.

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[36] The BLM had initially proposed three quantification points, Fort Benton, Virgelle, and Fred Robinson Bridge. Because the claim at Fred Robinson Bridge was the largest, the parties used this point to assess impacts of future development.

In May, 1994, the BLM submitted a proposal to the Commission for a reserved water right for instream flow for the BTCPRS. (Appendix D). The BLM proposed a year-round flow of 1,100 cfs. The Bear Trap Canyon Public Recreation Site Proposal was based on a limited survey of outfitters and guides done by the BLM to identify minimum instream flows necessary for safe recreational floating through the Canyon.

The Montana Power Company which owns and operates the Madison Dam had recently stipulated to a minimum release of 1,100 cfs from the Dam as part of the relicensing process with the Federal Energy Regulatory Commission. Montana Power Company has a senior water right claim for Madison Dam. A representative of the Montana Power Company testified before both the House and Senate Natural Resources Committees in favor of the Compact. Since there are no other intervening water users, the Compact contains a straightforward agreement for quantification of an instream flow right.

The instream flow water right for the Madison River as it passes through the BTCPRS is 1,100 cfs from January 1 to December 31 (year-round). The priority date is June 9, 1971.

ARTICLE III: UMNW&SR WATER RIGHT IMPLEMENTATION

This portion of the Compact sets out the volume limits by month on future water development under state law upstream from the UMNW&SR, how depletions from future water development will be calculated, what water uses will not be subtracted from the volume limits, how the volume limits will be administered, and what happens when a monthly volume limit is reached.

Available Water Supply

The Available Water Supply is the volume depletion limit for future water use (except as provided in Article III(C)) under state law in the Missouri River basin above Fred Robinson Bridge. Article III(A). The Joint Technical Report describes how these numbers were established. (Appendix C.)

The HYDROSS model included water use data through 1987. Instead of updating the model, the negotiating teams used the standardized method for calculating depletions for appropriations completed after January 1, 1988 and made sure the monthly volumes were adequate to cover these permits as well as future uses identified by the State. The depletions for appropriations completed after January 1, 1988 will be subtracted out of the AWS in the first annual report.

The volumes in the AWS are sufficient to provide for approximately 100,000 acres of new direct flow, full service irrigation, future municipal and industrial needs, and approximately 500,000 acre-feet of new storage (no storage facility may be build on the mainstem of the Missouri River). The State is not limited to these types of development in the future, the only limit on water use is volume. After the volume in any month is reached, the Missouri River basin above Fred Robinson Bridge will be closed to new appropriations that month. The uses not subtracted from the AWS under the Compact will not be subject to the basin closure. Article III(E).

Most of the Missouri River basin impacted by these negotiations is already closed, either temporarily or permanently, to many types of new appropriations. [37] There are also many obstacles to development in the basin, such as large senior water right claims, arsenic, local water availability, etc. The State is confident that these volumes will provide for all reasonable water needs into the future.

The water volumes if fully developed would not dewater the UMNW&SR or drop the flow below historic low flow in any month in the driest one year in ten (90% exceedence flow). In most years the remaining flow after development would meet or exceed the BLM's original instream flow proposal. The flows also reflect the natural hydrograph.

Method for Calculation of Monthly Depletions Subtracted from or Added to the Available Water Supply

The Compact sets out the methods used to calculate monthly depletions for a variety of uses from surface, ground or stored water sources. Article III(B). The specific method for DNRC to use to calculate depletions for each type of water use from each water source is attached to the Compact as Appendix 1. The specifics of how each depletion factor was derived is set out in the Joint Working Group Report. (Appendix C.) Except as provided in Article III(C), for each new water use the DNRC will subtract monthly depletions from the AWS monthly amounts. If an appropriation is revoked, modified, found invalid, or abandoned after December 31, 1987 the DNRC will calculate the previous depletion amounts and will added them to the AWS using the same procedure. Article III(D).

Depletions are standard (not measured) reduction amounts under the Compact. For example, depletions for 100 acres of sprinkler irrigation near Great Falls would be the same amount as depletions for 100 acres of flood irrigation near Wisdom. No term, condition, restriction, or limitation will be placed on any appropriation as a result of the Compact. Article I(6).

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[37] Mont. Code Ann. §§ 85-2-330, 341, and 343.

The state water reservations granted in the upper Missouri River basin have July 1, 1985 priority dates but have not been developed. A state water reservation is an enforceable right for future use under state law, so water set aside for a reservation is not "available." Therefore, the state water reservation depletions will be calculated and subtracted from the AWS the first year. If a reservation is modified or revoked, the volume of water previously subtracted from the AWS will be added back in. The exception to this is the state water reservation granted to the Bureau of Reclamation for the Virgelle Project. [38] It will not be subtracted from the AWS because the Bureau of Reclamation testified at the water reservation hearings that adverse impacts to the UMNW&SR could be mitigated by releases from Tiber Dam on the Marias River. Article III(B)(4).

Uses Not Subtracted from the Available Water Supply

The Compact specifies that some water uses will not be subtracted from the AWS. Article III(C). Some of these are small uses. Groundwater wells of 35 gallons per minute or less, not to exceed 10 acre feet per year, for any use are not subtracted. Surface water withdrawals of 35 gallons per minute or less, not to exceed 10 acre feet per year, for domestic use are not subtracted. Lawn and garden irrigation under 5 acres and instream stock uses are not subtracted. Non-consumptive uses of any size are not subtracted.

Late claims will not be subtracted from the AWS because, if valid, these pre-1973 rights are reflected in historic flows. Article III(C)(6). Conversely, water rights abandoned before December 31, 1987 would not be reflected in historic flows and would not be added to the AWS. Article III(D)(1).

Supplemental water uses will not be subtracted from the AWS. Article III(C)(3). These water rights are "supplemental" to water rights currently held. Article I(14). For example, the owner of a field currently irrigated from surface water may apply for a groundwater permit to get a more stable source of water. Because the new permit is to irrigate the same land that the previous surface water right did, it is supplemental. It was difficult to get a handle on supplemental water use because it may expand the water use from the historic pattern of use or it may not. Therefore, counting depletions for supplemental uses would be over-inclusive and not subtracting them is probably under-inclusive. New permits for supplemental water uses are not all that common and the negotiators finally decided not to subtract supplemental water from the AWS.

Federal and Tribal water rights will not be subtracted from the AWS. Article III(C)(7). This includes any water right that is recognized in satisfaction of a reserved water right claim or any individual claiming water rights derived from a

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[38] Water Reservation No. 72579-41T.

right created under federal law (i.e. Walton Rights). This was a difficult issue for the Federal Team. Other federal and Tribal water rights have not been quantified so assessing the impacts from future development under federal law created a great deal of uncertainty. The parties had agreed that federal and Tribal water rights would not affect the AWS. However, to accommodate some level of future development outside of the State system, the AWS was lowered in April, May and June to numbers proposed by the BLM based on their internal review. The AWS was also lowered in July and August to numbers sufficient to meet future water needs. See, Joint Technical Working Group Report (Appendix C). The Blackfeet Tribe originally had presented some concerns, but withdrew their objections to the Compact after the Solicitor's Office responded to their questions.

The Compact provides that no new mainstem impoundments may be built on the Missouri River. Article III(F). All existing impoundments can not be enlarged without consent of the Federal Energy Regulatory Commission. Montana Power Company (owner of the only non-federal dams on the Missouri River) and the BLM worked out the language for this provision and Montana Power Company supported the Compact in the legislature.

Administration and Enforcement

Each year the DNRC will calculate depletions from new appropriations issued using the Method for Calculation of Monthly Depletions, Appendix 1 to the Compact. Any adjustments to the AWS from review of completed appropriations will also be done at this time. The DNRC will send the BLM an annual report by March 15 for the previous years actions. The Compact provides for a cooperative review process, Article III(G)(3), in the event that the BLM has questions concerning the annual report. The DNRC makes all final decisions, but the BLM can submit written comments or call for an annual meeting to informally discuss its concerns. The BLM may seek de novo review of the annual report in a court of competent jurisdiction. Any court action is limited to the annual report for the previous year and impacts only the calculation of depletion amounts from the AWS and does not affect the appropriations issued or any other decisions of the DNRC.

The BLM enforces its water right by monitoring the AWS and may file a court action to ensure that the basin is closed to affected new appropriations for any month the AWS volumes have been expended.

There is no minimum instream flow established for the UMNW&SR. Therefore, based on the way the water right is defined, the BLM can not place a "call" on the River. The BLM also can not object to applications for new appropriations or changes in appropriations based on its water right for the UMNW&SR. Article III(H)(3).

ARTICLE IV: BTCPRS WATER RIGHT IMPLEMENTATION

The BTCPRS has a straightforward quantified water right. The Compact contains only a couple implementation provisions. The Compact provides that the instream flow use will not be changed to any other use. Article IV(B). An action for enforcement of the water right may be made in any court of competent jurisdiction. Article IV(D).

Almost all of the small tributaries that flow into the Madison River in the Bear Trap Canyon arise and flow through exclusively Federally managed lands. Only one unnamed tributary has any private land upstream from the BTCPRS. The Madison River basin is closed to many types of new appropriation. Mont. Code Ann. § 85-2-341. The BLM was concerned that, should the basin be reopened, future development could impact this tributary. The parties agree that DNRC would notify the BLM if the Madison River basin is reopened so that the BLM has the option of filing a state water reservation application for the unnamed tributary. Article IV(C).

ARTICLE V: GENERAL PROVISIONS

Nothing in the Compact "may be construed or interpreted in any manner" to impact the water rights of any Indian Tribes in Montana or to impact the rights of any other federal agencies in the state.

The Compact may not be used as precedent for litigation or for interpretation or administration of future compacts between the United States and the State, or the United States and any other states. The United States did not waive rights under State law to file objections in the water adjudication process or to file objections in the appropriate forum for water users exercising their water right inconsistent with a decree or permit.

The water right can not be abandonment by non-use. Instream flow rights recognized under the Compact run concurrently with any other non-consumptive water rights. And the United States may continue to seek water rights under State law for use inside or outside the boundaries of federal reservations for which there are water rights settled in the Compact.

ARTICLE VI: FINALITY OF COMPACT

The Compact went into effect on September 10, 1997, after it was respectively ratified by the Montana Legislature and approved by the U.S. Department of Interior and the U.S. Department of Justice.

The water rights described in the Compact are full and final settlement of the federal reserved water rights claims for the UMNW&SR and the BTCPRS. The agreement *does not* resolve any other claims, either reserved water right claims or water right claims based on state law, which the United States may assert in the adjudication. The Commission has terminated negotiations for any additional reserved water right claims not covered in the Compact.

APPENDICES TO THE COMPACT

Appendix 1 to the Compact is the Method for Calculation of Monthly Depletions Subtracted from the Available Water Supply. This was codified along with the Compact at Mont. Code Ann. § 85-20-501. Appendix 2 is a map of the UMNW&SR. Due to the size of the map it is not codified. A copy has been filed with the legislative record at the Historical Society, and is part of the original Compact filed with the Montana Secretary of State.

END

APPENDICES TO THE STAFF REPORT

Appendix A - Instream Flow Requirements for the Wild and Scenic Missouri River, U.S. Department of the Interior, Bureau of Land Management, Montana State Office (1984).

Appendix B - Methodology Manual For Conservation District Water Reservation Applications, December, 1991.

Appendix C - Joint Technical Working Group Report, December, 1997.

Appendix D - Assertion of Federal Reserved Water Right for Instream Flow in the Bear Trap Canyon of the Madison River, U.S. Department of Interior, Bureau of Land Management (May, 1994).

Appendix E - Map Upper Missouri National Wild and Scenic River [Appendix 2 - Water Rights Compact]

Appendix F - Missouri Breaks Freeflowing River, Pub.L. 94-486 (Oct. 12, 1976), 16 U.S.C § 1274.

APPENDIX A

INSTREAM FLOW REQUIREMENTS FOR THE WILD AND SCENIC MISSOURI RIVER

1984

U.S. Department of the Interior
Bureau of Land Management
Montana State Office

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

CONTENTS

INTRODUCTION 1
Background 1
Reasons for Preserving Instream Flow 2
Instream Flow Determinations 3
SUMMARY OF METHODS AND CRITERIA 5
Fish and Aquatic Habitat 5
Paddlefish 5
Side Channels 5
Riffles — Wetted Perimeter 6
Goose Nesting 8
Recreation 9
Maintenance of Channel Stability 10
RESULTS 11
Fish and Aquatic Habitat 11
Paddlefish 11
Side Channels 12
Riffles — Wetted Perimteter 14
Goose Nesting 14
Recreation Floating and Boating 19
Maintenance of Channel Stability 20
RECOMMENDED INSTREAM FLOW SCHEDULES 22
LITERATURE CITED 33

List of Maps, Tables and Figures

Map 1	Wild and Scenic Missouri River	Inside Back Cover
Table 1	Visitor Use of Wild and Scenic Missouri River Since 1976	2
Table 2	Location, Channel Length and Missouri River Flow at Which Side Channel Begins to Flow Water	7
Table 3	Criteria Necessary for Satisfactory Boating and Floating in Missouri Wild and Scenic River	10
Table 4	Physical Characteristics of Side Channels in the Fort Benton Gages Reach Compared to Flow of the Missouri River 1980	15
Table 5	Physical Characteristics of Side Channels in the Virgille Gages Reach Compared to Flow of the Missouri River 1980	16
Table 6	Physical Characteristics of Side Channels in the Fred Robinson Bridge Gages Reach Compared to Flow of the Missouri River 1980	17
Table 7	A Summary of Habitat Conditions in Monitored Side Channels at Declining Instream Flows, 1980	18
Table 8	Discharge at Virgelle Versus Floater Use	20
Tablel 9	1.5 Year Recurrence Discharges and Durations for Three Gaging Stations on the Missouri River	21
Figure 1	The Influent Flow of Side Channels	13
Figure 2	Example of a Side Channel With a Nearly Dewatered Midsection	13
Figure 3	Hydrograph of all Recommended Instream Flow Needs at Fort Benton	24
Figure 4	Hydrograph of All Recommended Instream Flow Needs at Virgille	25
Figure 5	Hydrograph of All Recommended Instream Flow Needs at Fred Robinson Bridge	26
Figure 6	Composite Hydrograph of All Recommended Instream Flow Needs at Fort Benton	27
Figure 7	Composite Hydrograph of All Recommended Instream Flow Needs at Virgille	28
Figure 8	Composite Hydrograph of All Recommended Instream Flow Needs at Fred Robinson Bridge	29
Figure 9	The Streamflows (1953-1982) Which are Equalled or Exceeded Either 50 or 90 Percent of the Time and the Recommended Instream Flow at Fort Benton	30
Figure 10	The Streamflows (1953-1982) Which are Equalled or Exceeded Either 50 or 90 Percent of the Time and the Recommended Instream Flow at Virgille	31
Figure 11	The Streamflows (1953-1982) Which are Equalled or Exceeded Either 50 or 90 Percent of the Time and the Recommended Instream Flow at Fred Robinson Bridge	32

INTRODUCTION

Background

The significant natural resources and scenic grandeur of the Upper Missouri River have been well known since the time of earliest exploration. The Lewis and Clark Expedition traversed it in May-June of 1805 with two pirogues and six dugout canoes. The river became a commercial artery in 1831 with the establishment of Fort Piegan at the mouth of the Marias River by James Kipp. Fort Piegan was replaced by Fort McKenzie, eight miles further up river, in 1832. Fort Lewis, some twenty miles above Fort McKenzie, was established in 1846, and it was replaced by Fort Benton at a downriver site the following year. During these years of commerce, the primary craft was the keel boat.

On June 17, 1859, the stern-wheeler *Chippewa* landed at Brule Bottom, the former site of Fort McKenzie. On July 2, 1860, the *Chippewa*, followed closely by the *Key West* reached Fort Benton, proving the river navigable by steamboat to that point.

The first documented use of the Upper Missouri as a recreation resource was in the fall of 1901. The noted author James Willard Schultz floated the river with his wife, Natahka, in a 19 foot long, flat-bottomed skiff. He wrote about this experience in *Forest and Stream* (12 installments between February 15 and May 24, 1902).

The river saw occasional recreational use over the years. The 1950's saw a major increase in interest about the Missouri as a recreation resource. In 1956, the Glasgow Chamber of Commerce sponsored the first of what was to become an annual river cruise. During the Bicentennial, the 20th annual Glasgow Cruise contained 76 boats, all motorized, ranging from a single rubber raft to several large craft in the 20-30 foot range, including one house boat.

The early 60's saw the formation of the first commercial cruise company in Fort Benton. There are now two of these companies in Fort Benton, and both utilize large pontoon boats and canoes. There are a total of 8 companies, some out of state, which provide commercial cruises and boat rentals.

In 1962, the Secretaries of the Interior and Army conducted a comprehensive study of the river between Fort Peck Reservoir and Fort Benton. The final report issued in 1963 listed a number of management alternatives ranging from full preservation to full development. In 1966, the State of Montana gave official recognition to the recreational values of this segment of the Missouri by designating it a component of the Montana Recreational Waterway System. A report from the Bureau of Outdoor Recreation (which later became the Heritage Conservation and Recreation Service) published in 1968, recommended protection of the free-flowing segment of the Missouri River between Coal Banks Landing and the western boundary of the Charles M. Russell National Wildlife Refuge.

The Wild and Scenic Rivers Act, PL 90-542, was approved October 2, 1968. Part of the Missouri River was included for study and potential addition to the National Wild and Scenic Rivers System. In January 1975, the Bureau of Outdoor Recreation released a report entitled *The Missouri River: A Wild and Scenic River Study*. The report recommended that the 128 mile reach between Coal Banks Landing to the old townsite of Rocky Point be included in the national system. During this same time period, legislative efforts were begun in the U.S. Congress to include the Upper Missouri in the national system.

On October 12, 1976, President Gerald Ford signed H.R. 15482 adding the Upper Missouri to the National Wild and Scenic Rivers System and granting the U.S. Bureau of Land Management administrative responsibility. The boundaries extend from Fort Benton downstream to Fred Robinson Bridge as shown on Map 1.

Public Law 94-486, which added the Upper Missouri to the national system, required the Bureau of Land Management to complete a management plan, to define the exterior management corridor and determine which of the three national wild and scenic river classifications best fit portions of the river. The final *Upper Missouri Wild and Scenic River Management Plan* was approved October 20, 1978. This document serves as a planning framework within which the Bureau of Land Management administers the river and its resources.[1]

Reasons for Preserving Instream Flow

The Missouri Wild and Scenic Area, with its superior recreation, aesthetic, and wildlife values, is of prominence because of one compelling component, the Missouri River. All activities and values center around the river. Since 1977, the Bureau of Land Management has actively managed the river corridor, employing a Wild and Scenic River staff composed of both seasonal and permanent employees. Recreational use data (Table 1) has been collected since 1976.

Table 1
Visitor use of Wild and Scenic Missouri since 1976

Year	Total Number of Users Per Year	Total Visitor Days of Use	Visitor Days of Boating During Summer Float Season
1976	6,009	15,083	9,313
1977	unavailable	unavailable	5,402
1978	unavailable	unavailable	8,218
1979	unavailable	unavailable	9,576
1980	unavailable	unavailable	6,877
1981	7,634	14,163	7,482
1982	9,656	16,216	7,260
1983	6,580	13,198	8,910

Activities such as hiking, hunting, observing wildlife, rock hounding and camping, in addition to the more obvious activities of boating and fishing, center around the Missouri River. In order to maintain these recreational values, adequate streamflows in the Missouri must be preserved.

In addition to the very practical reasons for preserving streamflows of the Missouri there are impelling legal reasons. It is generally accepted that Congress, in designating a wild and scenic river, intends that adequate streamflows be preserved to maintain the values of the river. Such an "implied reservation" must, therefore, be quantified and protected.

The Wild and Scenic Rivers Act (Public Law 90-542) states:

> "It is the policy of the United States that certain selected rivers of the Nation which, with their immediate environments possess outstanding remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or similar values shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of future generations."

[1]Paraphrased from Upper Missouri Wild and Scenic River Management Plan.

In addition, the law (Public Law 94-486) designating the Missouri as Wild and Scenic states:

> "To the extent and in a manner consistent with the purposes of the Wild and Scenic River Act, the Secretary shall permit such pumping facilities and associated pipelines as may be necessary to assure the continuation of an adequate supply of water from the Missouri River to the owners of lands adjacent to the River and for future agriculture use outside the river corridor."

The Wild and Scenic Rivers Act further states:

> "Designation of any stream or portion thereof as a national wild, scenic, or recreational river area shall not be construed as a reservation of the waters of such streams for purposes other than those specified in this Act, or in quantities greater than necessary to accomplish these purposes."

These above three sections clearly demonstrate that:

1. Wild and Scenic Rivers and their immediate environments are to be preserved and protected.

2. Pumping facilities and pipelines for agricultural use may be located within the defined corridor of the Missouri Wild and Scenic River, consistent with preservation of the values of the river environment.

3. The waters of a Wild and Scenic River are only reserved for the purposes specified by the Act and only in quantities necessary to accomplish these purposes.

It is, therefore, necessary to quantify the streamflows needed for preserving the values of the Wild and Scenic Area if future water uses are contemplated which would affect streamflows in the Wild and Scenic Missouri.

Instream Flow Studies Determinations

Instream flow studies were recommended in the final *Upper Missouri Wild and Scenic River Management Plan* of 1978. The objective was to determine the instream flow needs required to maintain fish and wildlife, vegetation and recreational benefits. These studies began in April 1979. The Bureau of Land Management and Montana Department of Fish, Wildlife, and Parks (MDFW&P) cooperatively conducted the studies. They were coordinated with the MDFW&P's ongoing fisheries inventory and planning study.

A final report, *Analysis of the Instream Flow Requirements for Selected Fishes in the Wild and Scenic Portions of the Missouri River*, dated March 1982, describes the flows necessary to maintain a variety of fish and invertebrate species in the Missouri. In addition, several other studies on the Missouri were used as reference material.

The MDFW&P conducted extensive goose nesting studies on the River from 1976-1981. Minimum flows have been quantified which will protect island goose nesting sites from mammalian predators. These flows are necessary to keep predators from crossing island side channels during the nesting season of mid-March to the first of June.

The BLM has also conducted studies from 1981-1983 in cooperation with MDFW&P to determine the flows required to maintain the depths necessary for recreational boating.

Lastly, the literature was researched to determine the flows necessary to maintain channel stability. Of main concern is the transport of suspended sediment and bed load through the system to maintain the channel configuration and size.

SUMMARY OF METHODS AND CRITERIA

The following provides a brief description of the significance of the study and the methods used in conducting the study. The specific criteria used to quantify instream flow needs is identified at the end of each section. The detailed study reports and other references are cited.

A. Fish and Aquatic Habitat

1. Paddlefish

Paddlefish are native to Montana and are found in both the Yellowstone and Missouri River drainages. Significant numbers of paddlefish are found seasonally in the lower Yellowstone River and in the Missouri River in the dredge cut complex below Fort Peck Dam. Another paddlefish population inhabits Fort Peck Reservoir. A portion of this population seasonally migrates upstream from Fort Peck Reservoir into the Wild and Scenic Missouri River to spawn.

The paddlefish was formerly abundant throughout much of the Mississippi/Missouri River System but has undergone a drastic decline since 1900 (Pflieger 1975, Rehwinkel 1975, Vasetskiy 1971). A combination of influences including overharvest and loss of habitat has contributed to this decline. Only six major, self-sustaining populations of paddlefish remain in the United States today, including the population in this study area (Berg 1980).

The annual migration of paddlefish from Fort Peck Reservoir into the Missouri River was studied during 1977, 1978, and 1979. The migration was monitored with boom suspended electrofishing apparatus. Survey counts were made of all paddlefish observed by the boat operator and dip netter during the electrofishing operation. Survey counts were compared with USGS flow records to determine the minimum flow required by paddlefish to reach identified spawning sites (Berg 1981).

Individual movements of 11 paddlefish were followed by radio telemetry in 1980. Equipment used for the study is described by Gardner and Berg (1982). Paddlefish with radio transmitters were relocated from fixed-wing aircraft. Radio tracking of the fish commenced April 22 and terminated July 16, 1980. A total of 48 relocations were made on the radio-tagged paddlefish. Relocation data were compared with USGS flow records to provide supplemental information on minimum flows required by paddlefish to move to upstream spawning areas.

The criterion used for maintenance of the paddlefish population is the minimum discharge required by paddlefish to move upstream from Fort Peck Reservoir to spawning areas. Spawning occurs during the spring of the year.

2. Side Channels

Studies conducted on the Missouri River from 1979 through 1981 indicated side channels provided critical habitat for rearing of several important fish species as well as habitat vital for producing forage fish (Gardner and Berg 1982). The period during which sufficient flow is required to maintain suitable habitat conditions in side channels for rearing and forage fish production extends from early June through August. Important fish species occupying the side channels during this time period include: young of the year, sauger, perch, buffalo, goldeye and variety of suckers and minnows. Other investigators have also found side channels provide critical habitat for rearing and forage fish production (Ellis et al. 1979, Funk and Robinson 1974, and Kallemeyn and Novotny 1977).

Islands and associated side channels are a major feature of the Missouri River in this area. Much of the diversity of fishes found here is related to habitat varieties in side channels. Side channels enable fish which require calmer, more protected water during some or all of their life

cycle to extend their distribution into reaches of the river which would provide very little habitat if only the main channel of the river were available. Since side channels are essential for maintaining the integrity of fish populations, extensive studies were made in 1980 to determine the amount of flow required to maintain suitable habitat conditions in side channels for rearing capabilities and forage fish production.

A variety of physical characteristics were monitored in 12 typical side channels of the Missouri River in 1980, as flow receded from the seasonal high point to the low point. The locations and physical aspects of the side channels are shown in Table 2. Cross-sectional transects were established in the side channel pool habitat type, which, as shown previously, was the most important habitat for rearing and forage fish. Measurements of width and depth were made at a variety of flow levels for each of the side channel pool transects. Side channel inlet flow and length of the channel were also measured and descriptive notes were recorded on the physical characteristics of the outlet of the side channel. The 12 side channels were surveyed by seining to monitor utilization for rearing and forage fish.

As flow in the river recedes from high to low flows, the amount of suitable habitat in side channels for rearing and forage fish generally declines, but the rate of habitat loss is not constant throughout the entire range of flows. For each side channel there is a certain instream flow which is required to maintain suitable habitat conditions in the side channel. The flow requirements vary from one side channel to another; some side channels require more flow than others to maintain suitable habitat. The flow required to maintain each side channel is indicated by a threshold point. Above the threshold point, reductions in flow of the main channel caused only very small losses of habitat in the side channels. Below the threshold point, habitat conditions in the side channel deteriorated rapidly and became inadequate for rearing and forage fish. Threshold points determined for individual side channels were grouped to formulate flow recommendations for a reach of stream.

The criterion used for maintaining these side channels is the minimum discharge necessary to maintain suitable habitats for fish fauna. Side channel discharges are needed from early June through the month of August.

3. Riffles — Wetted Perimeter

Flow recommendations were based on the wetted perimeter/inflection point method (Nelson, 1980). Wetted perimeter is the distance along the bottom and sides of a channel cross-section in contact with water. As the flow in the stream channel decreases, the wetted perimeter is not constant throughout the entire range of flows. There is a point, called an inflection point, on the curve of wetted perimeter versus flow at which the rate or loss of wetted perimeter is significantly changed.

Above the inflection point, large changes in flow cause only very small changes in wetted perimeter. Below the inflection point, the river begins to pull away from the riffle bottom, exposing the bottom at an accelerated rate.

The maintenance of suitable flows in riffles is essential for the Missouri River fish populations. Four apparent reasons are:

1. Production of aquatic invertebrates occurs primarily in riffle areas (Hynes 1970).

2. Riffles contain substantial standing crops of aquatic invertebrates and forage fish, the principal food organisms of important fish species in the Missouri River.

Table 2

Location, Channel Length and Missouri River Flow at Which the Side Channel Begins to Flow Water and Nearest USGS Gaging Station for the 12 Side Channels on the Middle Missouri River Monitored During 1980

No.	Name	Location T	R	S	River Miles From Ft. Peck[1]	Channel Length (miles)	Missouri River Flow at Inception of Influent Surface Flow (cfs)	Nearest Gaging Station
1.	Roosevelt Island	24N	8E	23	174	0.8	4,130	Fort Benton
2.	Pimperton Island	24N	9E	4	167	.7	9,100	Fort Benton
3.	Rowe Bayou	25N	10E	21	158	1.1	12,000	Fort Benton
4.	Loma Ferry Island	25N	10E	18	153	0.9	7,700	Fort Benton
5.	Spanish Island	25N	10E	1	146	1.4	12,000	Virgelle
6.	Three Islands	25N	11E	31	147	1.4	3,800	Virgelle
7.	Judith Island	23N	16E	26	86	.7	(5,000-8,970)	Virgelle
8.	Norris Island	23N	16E	25	86	1.2	16,000	Fred Robinson Bridge
9.	Lower Sturgeon Is.	23N	21E	6	55	0.6	9,600	Fred Robinson Bridge
10.	Snake Point Island	23N	21E	1	50	0.7	3,800	Fred Robinson Bridge
11.	Dillon Island	23N	23E	31	35	0.8	9,140	Fred Robinson Bridge
12.	Hammond Island	22N	23E	6	35	1.1	5,640	Fred Robinson Bridge

[1]Fort Peck Reservoir = 0 River Miles

3. Adequate flow must be maintained in riffle areas to allow for passage of migratory fish species.

4. Riffle areas provide critical habitat for the rare sicklefin and sturgeon chub populations of the Missouri River.

If flows in the Missouri River were reduced below the inflection point, the riffle bottom would be exposed at an accelerated rate, causing a decrease in riffle area and channel depth.

Riffles are also the area of a stream most affected by flow reductions (Bovee 1974, Nelson 1977). Consequently, the maintenance of suitable riffle conditions for food production should also maintain suitable conditions in pools and runs, areas normally inhabited by adult fish.

The wetted perimeter/inflection point method was applied to six riffle transects located in four typical riffles of the Missouri River in the Fort Benton gaged reach during 1980.

In addition, three riffle transects were located in the shallow Cow Island riffle of the Robinson Bridge gaged reach. Many times this riffle marked the uppermost point which steamboats of the 1800 era could ascend the Missouri River. Because of its shallow depth, it also was the most preferred ford crossing within hundreds of miles for buffalo, Indian tribes, and voyagers of the upper Missouri River country. The Cow Island riffle area has been identified as a potential barrier to up or downstream fish migration during low flows (Berg 1981). Because of the extensive riffles in the Cow Island area, a great diversity of riffle fish is found here. The sicklefin chub, a "Species of Special Concern" (Holton 1980), depends largely upon riffles located in the Cow Island area. The loss of this species due to inadequate flows would be significant, as the sicklefin chub is sparsely distributed throughout the entire length of the Missouri River (Pflieger 1975).

Also, the sturgeon chub, another "Species of Special Concern" (Holton 1980), is substantially more abundant in the Cow Island riffle area than in any other part of the Missouri River from Morony Dam to Fort Peck Reservoir. For these reasons, the Cow Island riffle area was identified as a critical riffle area. Adequate flow over this riffle must be maintained so that it can continue to provide its unique values.

The criterion used for maintaining riffle areas is the discharge at the point of inflection where any further reduction in discharge results in a large decrease in the wetted perimeter. Adequate wetted perimeter should be maintained in riffle areas from January 1 through December 31.

B. Goose Nesting

The Missouri River below Morony dam provides substantial habitat for nesting and rearing of Canada geese. Canada geese select islands in the river as preferred nest sites.

Maintaining adequate side channel flows is necessary to insure protection of Canada goose nests from mammalian predators. Under extreme low flow conditions predators have easy access to the islands and can significantly reduce goose production. The security of the islands is a primary factor in their selection as nest sites by Canada geese. This security is provided by adequate side channel flows. Adequate side channel flows provide the necessary water depth, width and velocity to discourage predator access and provide island security. Observation of side channels during numerous goose nesting studies have indicated that riffle thalweg depths of approximately 1.0 to 1.5 feet in the side channel will generally discourage predator access to islands (Dan Hook personal communication).

During the course of a five-year inventory and planning study from 1976 to 1980 on the Missouri River from Morony dam to Fred Robinson Bridge, data on 522 Canada goose nests were collected. The data on these 522 goose nests included such information as nest fate, nest success, habitat use and selection and relationships to stream flows.

During the summer and fall of 1980, five islands in the Carter Ferry to Robinson bridge section were selected for instream flow analysis using the WETP technique as described by Nelson (1980). These islands had active Canada goose nesting sites and were representative of typical nesting habitat.

The WETP technique was modified for use on side channels in the following manner. Bench marks were established on each side channel and headstakes placed on each side of the cross section. Cross sections were selected at riffle areas connecting the island to the main channels. Water elevations were recorded under various flow conditions and the side channels gaged at high, intermediate, and low flows. Some cross sections were only gaged at high and low flows. These side channel flow readings were then correlated to total river discharge at the nearest USGS gage station. Side channel profiles were surveyed under low flow conditions and the above data analyzed.

The data were then used to construct a curve of wetted perimeter versus side channel discharge for each island side channel cross section. Riffle thalweg depth of 1.0 to 1.5 ft. in side channels generally occurred at flow levels associated with the inflection point of the wetted perimeter/side channel discharge curve. From these curves inflection points were determined and side channel flow at these points recorded.

A curve was then prepared for each side channel using gaged side channel flows versus correlated total river flows from the USGS gage stations. The inflection point side channel flow was then applied to this curve to determine the total Missouri River discharge which would represent the minimum flow for each side channel.

The criterion for providing adequate protection of the islands was determined to be the discharges necessary to maintain a riffle thalweg depth of 1.0 to 1.5 feet in the side channel. Goose nesting occurs from March 15 until June 1.

C. Recreation

There are a variety of recreational uses associated with the Wild and Scenic River. In the broad context the term "floating the river" actually encompasses such diverse recreation as pursuing historical interests, viewing scenery, photography, swimming, camping, observing wildlife, hiking, fishing, rock hounding, and hunting.

The instream flow needs reflect the type of watercraft used rather than the actual recreational activity. Based upon the publication "Methods of Assessing Instream Flows for Recreation" by Ronald Hyra, 1977, the following are the minimum depth requirements for safe watercraft use.

Watercraft Type	Minimum Safety Depths
Boats - under 50 hp	3 feet
Rafts/inner tubes	2 feet
Canoes/Kayaks	.75 feet

These criteria are minimum and not sufficient for a satisfactory boating or floating experience. These minimum depth requirements were used as a base. From this base satisfactory streamflows were calculated by assigning a percent of the channel width that must meet or exceed the minimum depth. Much of recreational use involves just drifting downstream, rather than actively paddling and selecting suitable channels. For this reason it was determined that a significant percent of the

channel width should have the minimum depth. Power boats are more maneuverable and therefore less channel width is needed for navigation at the minimum depth. Also considered in determining a suitable channel width was the amount of use by each watercraft type during the recreation season. Canoes and kayaks are used most often comprising 81% of the total use (Table 3). Based upon the above information a percent of channel width available at shallow passages was assigned for each watercraft type. These assignments represent subjective determinations rather than actual calculated figures.

Table 3

Criteria Necessary for Satisfactory Boating and Floating in the Missouri Wild and Scenic River

Watercraft Type	Percent of Total Watercraft Use	Minimum Depth	Percent of Continuous Channel Width Available at Shallow Passages
Boats - under 50 hp	14	3 feet	20%
Rafts/inner tubes	5	2 feet	25%
Canoes/kayaks	81	.75 feet	40%

Studies using cross sectional transects and the WETP program were made at Dauphin Rapids and Cow Island which are shallow passages on the river.

The criterion used for maintaining recreational floating and boating is the discharge necessary to provide for the safe passage of recreational watercraft over a designated portion of the channel width. Recreational floating occurs from May 15 through November 15.

D. Maintenance of Channel Stability

The purpose for identifying streamflows for channel stability is to maintain the existing channel geometry for recreational, fish and wildlife, and aesthetic purposes. A literature review "Securing Favorable Condition of Water Flows" by Dave Rosgen, USFS, was used to provide the background material necessary to establish recommended streamflows.

The entire range of stream discharges contributes to the form and characteristics of the river system. Of these discharges, the bankfull discharge is the most important. It is the discharge at which sediment movement, including bed load, results in the average morphologic characteristics of the channel (Dunne and Leopold 1978, Rosgen 1982).

Without the bankfull discharge occurring periodically, sediment would be deposited in the now active channel reducing channel capacity and access to the channel bank. Vegetation would encroach upon the now active channel and ground water recharge to the present channel bank and floodplain would be reduced. These changes would have a detrimental effect on the recreational, fish and wildlife, and aesthetic values of the river (Yochem 1983).

For these reasons, the bankfull discharge was determined to be the criterion upon which to make streamflow recommendations for channel maintenance and stability.

RESULTS

The results which are discussed below have tied streamflow needs to three U.S. Geological Survey gaging stations located on the Missouri River. The three gaging stations are Fort Benton, Virgelle, and Fred Robinson Bridge (referred to as Landusky in USGS publications). In some cases there is reference to stream reaches. Map 1 can assist in identifying the referenced gaging stations and stream reaches. In some cases, a study may be tied directly to a particular gage station and the streamflows up or down stream extrapolated from the historical gaging record. Such is the case with paddlefish.

A. Fish and Aquatic Habitat

1. Paddlefish

Berg (1981) found that paddlefish require a flow of 14,000 cfs in the Virgelle gaged reach of the Missouri River to complete their annual spring migration to spawning sites. To maintain the paddlefish migration, flow should remain at or above 14,000 cfs during the 48 day period from May 19 through July 5 in the Virgelle gaged reach. This time period was selected because it coincides with the biological requirements of paddlefish.

Results of paddlefish radiotelemetry studies conducted in 1980 firmly support these conclusions. Movement of radio-tagged paddlefish to spawning sites occurred during the high flow period from late May through early July (Gardner and Berg 1982).

Based on these considerations, a flow of 14,000 cfs is recommended for the Virgelle gaged reach of the Missouri River during the paddlefish spawning period from May 19 through July 5. This reach extends from the confluence of the Marias River to the confluence of the Judith River.

Upstream from the Virgelle gage, the reach of the Missouri River from Morony Dam to the confluence of the Marias River is gaged by the Fort Benton USGS station. Based on calculations made from USGS data gathered at Virgelle and Fort Benton gage stations, it was determined that the Missouri River at Fort Benton contributes 90.16 percent of the median flow of the Missouri River at Virgelle during the paddlefish spawning period from May 19 through July 5.

Therefore, to maintain the annual spring paddlefish migration in the Missouri River, a flow of 12,622 cfs is recommended for the reach of the Missouri River from Morony Dam to the confluence of the Marias River. This flow should be maintained from May 19 through July 5.

The reach of the Missouri River from the confluence of the Judith River to Fort Peck Reservoir is gaged by the Robinson Bridge (Landusky) USGS station. Flow accretion in this reach of the river during the paddlefish spawning period is mostly attributable to the contribution of the Judith River. Based on calculations made from USGS data gathered at the Virgelle and Robinson Bridge gage stations, it was determined that median flow of the Missouri River at Robinson Bridge amounts to 108.48 percent of the median flow of the Missouri River at Virgelle during the paddlefish spawning period from May 19 through July 5. Therefore, to maintain the annual spring paddlefish migration in the Missouri River, a flow of 15,187 cfs is recommended for the reach of the Missouri River from the confluence of the Judith River to Fort Peck Reservoir. This flow should be maintained from May 19 through July 5.

The paddlefish is officially listed as a "Species of Special Concern — Class A" in Montana (Holton 1980), and only six major self-sustaining populations remain in the United States. Adequate flows are essential to maintain the Fort Peck Reservoir/Missouri River paddlefish population.

2. Side Channels

To facilitate interpretation of instream flow data, the river was separated into three reaches. The reaches extended from Morony Dam to the confluence of the Marias River, from the confluence of the Marias to the confluence of the Judith River, and from the confluence of the Judith River to Fort Peck Reservoir. Streamflow in these reaches was monitored by the Fort Benton, Virgelle and Robinson Bridge gage stations, respectively. Tables 4 through 6 summarize various physical parameters measured in each side channel during declining flows.

Influent surface flow ceased in 7 of the 12 side channels at an intermediate point of the declining surface runoff period (July 18-29, 1980). Even though there was no influent surface flow to the side channels, they did not entirely dewater, but were then supplied by subsurface seepage and a backwater flow from the main channel. Consequently, the water level in the side channels continued to decline in response to the decreasing instream flows even after influent surface flow had ceased.

The influent surface flow of a side channel was a major factor controlling both the channel length and depth (Figure 1). For example, average channel length decreased from 0.75 miles to 0.31 miles, or by 58 percent, in side channels 2, 4, 7, 9, and 11 between the time the side channels had an influent flow and when the flow recently had ceased.

Water depth is the physical dimension of habitat most important for the fish communities in these side channels. In several of the side channels the depths throughout the channel were not uniform, but exhibited shallow, wide segments (Figure 2) as well as deep segments. For transects located in these shallower portions of the side channels, mean depth declined from 1.9 to 0.6 feet, or a 70 percent loss between the time the side channels had an influent flow and when the flow recently had ceased. For the same side channels and period, the deeper portions of the side channels exhibited only a 32 percent average decline.

This illustrates that the shallower portions of the channel were more susceptible to dewatering. Dewatering occurred to a greater degree between the period when there was an inlet flow and when the inlet flow recently had ceased. In some cases when segments of shallow pool areas were completely dewatered, the loss of channel length was large. Dewatering of these shallower pool areas occurred inside channels 4, 9, 11, and 12 during low stream flows. At this time many of the disconnected large pools (isolated from river) with moderate depths were warmer than the ambient river temperature. With the increase in water temperature of the pools, dissolved oxygen probably declined to low levels. It is evident that a side channel must at least be connected at the outlet to allow for adequate circulation of the side channel water. The channel width did not appear to change at the same rate as average depth. This was because most of the transects in the side channels had steep channel banks.

The 12 side channels were assessed in terms of suitability of the habitat for the fish fauna at declining stream flows. The criteria used were average depth, length of channel loss and depth of channel at outlet. An average depth of at least 0.65 ft. with maximum depths of 1.3-1.6 ft. was considered the minimum criterion required for adequate cover in the side channels. This criterion was based on fish sampling in these areas during 1979 and 1980. Table 7 is an evaluation of the side channels' suitability at the instream flow levels when they were surveyed. It was evident that at instream flows of 4360 cfs in the Fort Benton gaged reach, serious losses of habitat had occurred and habitat conditions in two of the four side channels were inadequate. At 4310 cfs, habitat in three of the four side channels was considered inadequate. In the Virgelle gaged reach, only one of the three side channels was severely affected by the lower base flows. This side channel was disconnected from the river. Consequently, habitat conditions were inadequate when flow had reached 4980 cfs. The other two side channels in this reach were in satisfactory condition at the low flow of 4510 cfs gaged on September 25, 1980. Four of the five side channels surveyed in the Robinson Bridge gaged reach were classified as inadequate at the

Figure 1: The influent flow of side channels was an important factor maintaining both physical channel features and the fish communities utilizing this habitat.

Figure 2: Example of a side channel with a nearly dewatered mid-section.

lower instream flow of 5640 cfs recorded September 7, 1980. In summary, habitat conditions in 8 of the 12 monitored side channels were inadequate at the lower instream flows experienced in 1980.

The 12 side channels which were selected for monitoring in 1980 represented the various types found throughout the study area. Therefore, the effects of flow reductions on these 12 side channels exemplified the effects on the unmonitored side channels and backwaters. During the lower flow period in 1980 habitat conditions in both monitored and unmonitored side channels were inadequate for rearing and forage fish production. At this flow, the river's capability for rearing of important sport and commercial fish (i.e., sauger, buffalo, goldeye) and forage fish was significantly reduced.

The relationship between the monitored side channels' habitat condition and mainstem flows indicated that minimum flows of 4500 cfs, 5400 cfs, and 5800 cfs at Fort Benton, Virgelle and Robinson Bridge gaged sections, respectively, are required to maintain suitable conditions in side channels for rearing and forage fish production. Since flow and channel dimensions increase substantially between reaches minimum flow recommendations increase progressively in downstream reaches. The recommended increases in flow correspond to normal water accretion as reported by USGS surface water runoff monitoring. Since the side channel habitat is used for rearing and forage fish production from June 1 through August 31, the recommended flows should be maintained during this period.

3. Riffles — wetted perimeter

For the Fort Benton riffle transect, the WETP program was calibrated to field data collected at flows of 10,900, 7,500, 6,400, and 4,500 cfs. This inflection point on the wetted perimeter—discharge relationship occurs at 3,700 cfs for the composite of seven riffle transects located in the Fort Benton study area.

For the Cow Island riffle transects, the WETP program was calibrated to field data collected at flows of 13,500, 8,830, 8,200, and 5,660 cfs. The inflection point on the wetted perimeter—discharge relationship occurs at 4,700 cfs for the composite of three transects located in the Cow Island riffle as measured at the Fred Robinson Bridge.

Adequate flows in the Virgelle reach are necessary to maintain riffles in the Robinson Bridge gaged reach. The reach of the Missouri from the confluence of the Marias River to the confluence of the Judith River is gaged by the Virgelle USGS station. Based on calculations made from USGS data gathered at the Virgelle and Robinson Bridge gage stations, it was determined that the Missouri River at Virgelle contributes 91.6 percent of the median flow of the Missouri River at Robinson Bridge during the base flow period. Therefore, a flow of 4,305 cfs is sufficient to maintain riffle areas in the Virgelle reach. This base flow is a yearlong requirement.

B. Goose Nesting

The Canada goose nesting season on the Missouri River extends from March 15 to June 1 with the peak in nest initiation occurring during the first week of May.

Data from four different islands were analyzed for the Fort Benton section. These data indicate an average minimum flow of 4,887 cfs, as measured at the Fort Benton USGS gage station. The minimums for these four side channels ranged from 4,400 to 5,200 cfs.

Based upon historical U.S. Geological Survey gaging records (1953-1982), the streamflow at Virgille are 114% of those at Fort Benton during the March 15 to June 1 period. Therefore, the recommended flow at the Virgille gage is 5,571 cfs.

Table 4

Physical Characteristics of Side Channels in the Fort Benton Gaged Reach Compared to Flow of the Missouri River in 1980

Side Ch. No.	Date	Missouri River Flow (cfs)	Channel Influent Flow (cfs)	Total Channel Length (miles)	Transect 1			Transect 2			Transect 3		
					Avg. Depth	Max. Depth	Width	Avg. Depth	Max. Depth	Width	Avg. Depth	Max. Depth	Width
					(yards)			(yards)			(yards)		
1	7/27	9,778	194	0.81	0.49	0.76	23.8	0.88	1.40	23.5	0.76	0.97	20.7
	8/07	6,079	49	0.81	0.24	0.52	21.3	0.76	1.09	21.9	0.52	0.73	20.5
	9/10	4,130	tr [1]	0.81	0.06	0.33	17.9	0.64	0.94	20.7	0.36	0.55	18.8
2	7/18	9,097	tr	0.68	0.76	1.04	15.2	0.55	1.03	14.9	0.70	0.88	19.1
	8/25	4,610	0	0.31	0	0	0	0.43	0.73	10.3	0.46	0.64	17.3
	9/24	4,218	0	0.25	0	0	0	0.40	0.67	9.1	0.33	0.49	16.1
3	7/19	7,699	0	1.0	0.27	0.40	14.9	0.46	0.64	22.2	0.46	0.64	25.6
	8/26	4,360	0	0.62	0.15	0.18	11.6	0.09	0.12	13.1	0.12	0.18	14.0
	9/25	3,858	0	0.62	0	0	0	0.06	0.09	11.9	0.09	0.15	12.8
4	7/19	7,699	tr	0.87	0.88	1.34	28.1	0.36	0.52	28.3			
	8/26	4,360	0	0.25	0.58	0.91	24.1	0.06	0.09	12.2			
	9/25	3,858	0	0.25	0.58	0.88	24.1	0.06	0.09	8.8			

[1]Flow less than 5 cfs

Table 5

Physical Characteristics of Side Channels in the Virgelle Gaged Reach Compared to Flow of the Missouri River in 1980

Side Ch. No.	Date	Missouri River Flow (cfs)	Channel Influent Flow (cfs)	Total Channel Length (miles)	Transect 1			Transect 2			Transect 3		
					Avg. Depth	Max. Depth	Width	Avg. Depth	Max. Depth	Width	Avg. Depth	Max. Depth	Width
					(yards)			(yards)			(yards)		
5	7/20	9,058	0	1.1	0.67	0.91	24.1		[2]		0.76	1.12	30.6
	8/27	5,430	0	1.1	0.40	0.58	20.8	0.46	0.64	23.2	0.49	0.85	28.5
	9/25	4,508	0	1.1	0.36	0.52	20.5	0.43	0.54	22.9	0.43	0.73	27.5
6	7/20	9,058	477	1.4	1.40	1.88	43.0	0.58	0.70	34.9	1.25	1.73	22.3
	8/27	5,430	81	1.4	0.85	1.16	40.2	0.30	0.40	31.2	0.94	1.37	21.4
	9/26	4,769	32	1.4	0.76	1.03	39.3	0.21	0.27	28.8	0.79	1.22	20.5
7	7/8	13,396	212	0.68	0.54	0.73	19.8	0.88	1.22	22	0.70	0.79	20.5
	7/27	8,966	28	0.04	0.27	0.36	17.0	0.73	0.91	15.5	0.36	0.46	19.5
	9/5	4,977	—	0		[3]			[3]			[3]	

[2]Did not take depth measurement at transect

[3]Side channel's outlet and inlet dry

Table 6

Physical Characteristics of Side Channels in the Fred Robinson Bridge Gaged Reach Compared to Flow of the Missouri River in 1980.

Side Ch. No.	Date	Missouri River Flow (cfs)	Channel Influent Flow (cfs)	Total Channel Length (miles)	Transect 1			Transect 2			Transect 3			Transect 4		
					Avg. Depth	Max. Depth	Width (yards)	Avg. Depth	Max. Depth	Width (yards)	Avg. Depth	Max. Depth	Width (yards)	Avg. Depth	Max. Depth	Width (yards)
8	7/9	15,394	0[1]	1.1	0.49	0.70	10.9	0.67	0.82	13.4						
	7/27	9,489	0	1.0	0.24	0.40	7.9		[2]							
	9/5	5,599	0	0.7	—	—	—	0.12	0.18	9.1						
9	7/10	14,596	70.6	0.6	0.43	0.67	13.1	0.85	0.97	16.7	0.97	1.28	20.6			
	7/28	9,266	0	0.6	0.21	0.36	8.5	0.54	0.64	15.8	0.73	0.94	18.8			
	9/6	5,288	0	0.19	0.06	0.09	4.0	0.40	0.49	15.2	0.40	0.61	17.3			
10	7/10	14,596	727.2	0.68	0.97	1.37	26.4	1.28	1.58	28.8	1.22	1.64	30.2			
	7/28	9,266	349.5	0.68	0.64	0.91	25.5	0.91	1.16	30.1	0.82	1.22	29.5			
	9/6	5,288	70.6	0.68	0.36	0.61	22.5	0.64	0.85	27.1	0.54	0.82	24.6			
11	7/12	15,497	243.6	0.7	0.79	1.06	17.0	0.52	0.67	21.3	1.09	1.58	19.2			
	7/29	9,136	tr[3]	0.7	0.33	0.54	14.9	0.12	0.18	18.5	0.73	1.19	17.3			
	9/7	5,637	0	0.43	0.27	0.49	14.9	0.06	0.06	11.2	0.54	0.91	15.8			
12	7/13	13,598	243.6	1.1	0.70	0.94	20.7	0.76	1.12	27.1	0.94	1.16	21.3	0.76	1.00	25.8
	7/30	8,776	88.3	1.1	0.52	0.67	17.3	0.54	0.85	24.6	0.61	0.76	19.8	0.46	0.54	24.0
	9/7	5,637	tr	0.31	0.27	0.33	14.3	0.30	0.58	21.0	0.30	0.46	19.2	0.15	0.33	23.6

[1]Denotes zero flow or depth

[2]Did not take depth measurement at transect

[3]tr denotes a flow less than 5 cfs

Table 7

A Summary of Habitat Conditions in Monitored Side Channels at Declining Instream Flows, 1980

Side Channel No.	Reach of River	Date	Missouri River Gaged Flow (cfs)	Condition of Side Channel Habitat[1]
1	Fort Benton	7/17	9780	Suitable
		8/20	6080	Suitable
		9/10	4130	Inadequate
2	Fort Benton	7/18	9100	Suitable
		8/25	4610	Suitable
		9/24	4220	Suitable
3	Fort Benton	7/19	7700	Suitable
		8/26	4360	Inadequate
		9/25	3860	Inadequate
4	Fort Benton	7/19	7700	Suitable
		8/26	4360	Inadequate
		9/25	3860	Inadequate
5	Virgelle	7/20	9060	Suitable
		8/27	5440	Suitable
		9/25	4510	Suitable
6	Virgelle	7/20	9060	Suitable
		8/27	5440	Suitable
		9/26	4770	Suitable
7	Virgelle	7/8	13400	Suitable
		7/25	8970	Suitable
		9/25	4980	Inadequate
8	Robinson Bridge	7/9	15400	Suitable
		7/27	9490	Suitable
		9/5	5600	Inadequate
9	Robinson Bridge	7/10	14600	Suitable
		7/28	9270	Suitable
		9/6	5290	Inadequate
10	Robinson Bridge	7/10	14600	Suitable
		7/28	9270	Suitable
		9/6	5290	Suitable
11	Robinson Bridge	7/12	15500	Suitable
		7/29	9140	Suitable
		9/7	5640	Inadequate
12	Robinson Bridge	7/15	13600	Suitable
		7/30	8780	Suitable
		9/7	5640	Inadequate

[1]Suitable rating = at or above the threshold point; Inadequate rating = below the threshold point

The final side channel data is for the Cow Island section of the Missouri River. This island was located below the power plant ferry. Data from this cross section indicate a minimum flow of 7,100 cfs, as measured at the Landusky USGS gage station.

C. Recreational Floating and Boating

A very important consideration for maintaining adequate streamflows is accommodation of safe navigation for recreational watercraft.

To determine the streamflows necessary for watercraft use, the following criteria was applied to cross sectional transect data:

Watercraft Type	Minimum Depth	Percent of Continuous Channel Width Available at Shallow Passages
Boats - under 50 hp	3 ft.	20%
Rafts/innertubes	2 ft.	25%
Canoes/Kayaks	.75 ft.	40%

There were four cross sectional transects established at Dauphin Rapids and three at Cow Island. Using the WETP program the following streamflows were identified as meeting the criteria:

	3 ft — 20%	2 ft — 25%	.75 ft — 40%
Dauphin Rapids	8,000 cfs	4,950 cfs	2,900 cfs
Cow Island	8,300 cfs	5,600 cfs	3,050 cfs

At Dauphin Rapids, for example, a flow of 8,000 cfs is needed to provide a minimum depth of 3 ft. for a continuous 20 percent of the channel width. A flow of 4,950 cfs is needed to provide a minimum depth of 2 ft. for a continuous 25 percent of the channel, etc.

Long-term streamflow records indicate the 8,000 cfs and 8,300 cfs, which meet the 3 ft. criteria are above the historic mean monthly streamflow for August, September, October, and November. Damage has occurred to large power boats using the Missouri during these months. There is, therefore, not a great amount of large powerboat use after mid-July because of the naturally occurring streamflows.

Because powerboat usage declines after mid-July, it is satisfactory to apply the 2 foot criteria after July 15th. This criteria would provide for a minimum 2 ft. depth over a continuous 25% of the channel width. Small power boats exercising care can make use of the river under these conditions.

For the period of May 15th through July 15th streamflows of 8,000 cfs at Daughin Rapids and 8,300 cfs at Cow Island are sufficient for all recreational uses.

For the July 15th through November 15th period streamflows of 4,950 at Daughin Rapids and 5,600 at Cow Island are adequate to support all recreational uses except large power boats.

Historical U.S. Geological Survey gaging records (1953-1982) were used to determine the streamflows required at the Virgelle and Fort Benton gage. For the May 15 through July 15 period the mean streamflows at Virgelle are 0.90 and at Fort Benton 0.77 of the streamflows at Landusky. For the July 15 through November 15 period, the mean streamflows at Virgelle are 0.92 and at Fort Benton 0.80 of the streamflows at Landusky. Using the recommended flows for Cow Island, the following recommended streamflows were calculated.

Virgelle	May 15 - July 15	8,300 x 0.90 = 7,470 cfs
	July 15 - November 15	5,600 x 0.92 = 5,150 cfs
Fort Benton	May 15 - July 15	8,300 x 0.77 = 6,390 cfs
	July 15 - November 15	5,600 x 0.80 = 4,480 cfs

Floater use data was examined in order to determine if there was any relationship between floater use and streamflow. Specifically, if floater use declined during months of low streamflows. User data was available for the years 1976-1983 excluding 1979 and September 1980 and covered the months June, July, August and September.

Streamflows at the Virgelle gage were summarized for the same period with a mean daily streamflow determined for each of the above months. Of the 27 months included in the study, 5 months had a mean daily streamflow below the flows recommended in this report. Floater use during these months was then compared to the mean floater use for that particular month (Table 8).

Table 8
Discharge at Virgelle Versus Floater Use

Month	Mean Daily Flow in cfs at Virgelle Gage	Recommended Streamflow	Number of Floaters	Mean Floater Use for the Month 1976-1983*	% of Mean Floater Use
June 1977	4646	7470	439	479	91.6
July 1977	4027	7470(July 1-15) 5150(July 15-30)	400	724	55.2
Aug. 1977	4534	5150	138	471	29.3
Sept. 1977	3990	5150	32	197	16.2
Sept. 1981	4879	5150	184	197	93.4

*1979 and September 1980 data not available.

In every case where mean daily streamflow for a given month did not meet the recommended streamflow, floater use was below the mean. This may indicate that low streamflows adversely effect the quality of floating to the point of reducing the number of floaters. In any event, the table does demonstrate that there was below average use of the river when streamflows were below those recommended in this report.

A related streamflow consideration is that of access to established campsites by watercraft. Campsite studies indicated that reduction in streamflows resulted in a decrease in the quality of boat landing sites. Using streamflow records at the Virgelle gage, watercraft landing difficulties were first recorded at a discharge of 10,800 cfs. The incidents of landing difficulties increased as streamflows decreased. At a discharge of between 5,500 to 6,500 cfs, there were several locations exhibiting landing difficulty. The most frequent problems were shallow mud flats which primarily effect motor boats. At a streamflow of below 5,000 cfs a significant number of landings are adversely affected for both motorized craft and canoes.

D. Maintenance of Channel Stability

Based upon the literature presented by Rosgen (1982), it was concluded that the bankfull discharges are the most important in maintaining the morphologic characteristics of the Wild and Scenic River.

The 1.5 year recurrence interval approximates bankfull discharge (Leopold et al. 1964, Emmett 1972). Thirty years of United States Geological Survey gaging records were used at three points on the river to determine the 1.5 year recurrence interval discharge. The records were also used to determine the average number of days per year this discharge was equalled or exceeded. Table 9 illustrates the results. The bankfull discharge and the historical duration of that discharge are the two dominant components which result in the average shape and form of the Missouri River channel. Bankfull discharge occurs about 2 out of 3 years and over the long-term 16 days per year. It is during this period, the spring of the year, that sediment including bed load is transported through the system. Sediment deposition occurring from tributary runoff is also moved through the system preventing channel aggredation.

Table 9

1.5 Year Recurrence Discharges and Durations for Three Gaging Stations on the Missouri River

Station	1.5 Yr. Recurrence Discharge in cfs	Average Number of Days per Year Discharge is Equalled or Exceeded	Length of Record
Fort Benton 06090800	21,200	15.4	1953-1982
Virgelle 06109500	22,600	16.9	1953-1982
Landusky 06115200	26,200	16.5	1953-1982

RECOMMENDED INSTREAM FLOW SCHEDULES

The instream flow recommendations for the river are a composite of all the study results presented earlier. The recommendations are made at all 3 of the stream gaging stations on the river. The following is a summary of recommendations.

Fort Benton Gage — Includes the Missouri River from Fort Benton downstream to the confluence of the Missouri River and the Marias River (see map 1).

Use	Recommended Streamflow	Time Period
Fish and Aquatic Habitat		
Paddlefish	12,622 cfs	May 19 - July 5
Side Channels	4,500 cfs	June 1 - August 31
Riffle Areas	3,700 cfs	Yearlong
Goose Nesting	4,887 cfs	March 15 - June 1
Recreation	6,390 cfs	May 15 - July 15
Recreation	4,480 cfs	July 15 - November 15
Channel Stability	21,200 cfs	16 days between March 15 and July 15

Virgelle Gage — Includes the Missouri River from the confluence of the Marias River to the confluence of the Judith River (see map 1).

Use	Recommended Streamflow	Time Period
Fish and Aquatic Habitat		
Paddlefish	14,000 cfs	May 19 - July 5
Side Channels	5,400 cfs	June 1 - August 31
Riffle Areas	4,305 cfs	Yearlong
Goose Nesting	5,571 cfs	March 15 - June 1
Recreation	7,470 cfs	May 15 - July 15
Recreation	5,150 cfs	July 15 - November 15
Channel Stability	22,600 cfs	16 days between March 15 and July 15

Landusky Gage — Includes the Missouri River from the confluence of the Judith River to the Fred Robinson Bridge (see map 1).

Use	Recommended Streamflow	Time Period
Fish and Aquatic Habitat		
Paddlefish	15,187 cfs	May 19 - July 5
Side Channels	5,800 cfs	June 1 - August 31
Riffle Areas	4,700 cfs	Yearlong
Goose Nesting	7,100 cfs	March 15 - June 1
Recreation	8,300 cfs	May 15 - July 15
Recreation	5,600 cfs	July 15 - November 15
Channel Stability	26,200 cfs	16 days between March 15 and July 15

The recommended streamflows are depicted in hydrograph form on Figures 3, 4, and 5. Many of the streamflow recommendations overlap during various months of the year. In those situations the

greatest streamflow is recommended. As an example, on Figure 3, during the month of June there are recommended streamflows of 12,622 cfs for paddlefish, 6,390 cfs for recreation, and 4,500 cfs for side channels and 3,700 cfs for riffle maintenance. The 12,622 cfs would, therefore, be recommended for the month of June. Figures 6, 7, and 8 further summarize the recommended streamflows into one recommended schedule of flows for each gaging station reach.

The channel stability streamflows may be treated somewhat differently than the others. Channel stability flows are not necessary every year but should occur approximately 2 out of 3 years. On a long-term average they are required 16 days per year or 24 days if they occur 2 out of 3 years. When the natural spring runoff is sufficient to reach the identified channel stability streamflows, it is recommended that these streamflows be maintained for a long-term average of 16 days per year. If, for example, they occur 2 out of 3 years, then they should be maintained for 24 days in order to maintain the 16 days per year average.

Some of the streamflow requests involve very high flows, particularly for paddlefish and channel maintenance. Depletions during these high flow periods, which do not materially change the frequency of occurrence of the requested flows would be acceptable.

In other words, due to the high flows involved for paddlefish and channel maintenance, minor depletions from these recommended flows could be accommodated.

Figures 9, 10 and 11 illustrate by month the streamflows with the 50 percent and 90 percent excedeence frequency. Thirty years of U.S. Geological Survey data was used to determine the values. A 50 percent exceedence frequency means that 50 percent of the time streamflows are equal or greater than the indicated flow. Also illustrated are the recommended streamflows. The three figures illustrate that the 50 percentile streamflows nearly always satisfy the recommended instream flow. The only exceptions are at the end of May and the beginning of July where the recommended flows exceed the 50 percentile. This is only the case because the figures show a monthly percentile rather than daily. On a daily basis all of the recommended streamflows are exceeded by the 50 percentile flow.

Except for the high flows required for paddlefish from May 19 to July 5, the 90 percentile flows are verly close the the recommended instream flows. Thus, 90 percent of the time most of the recommended streamflows are met.

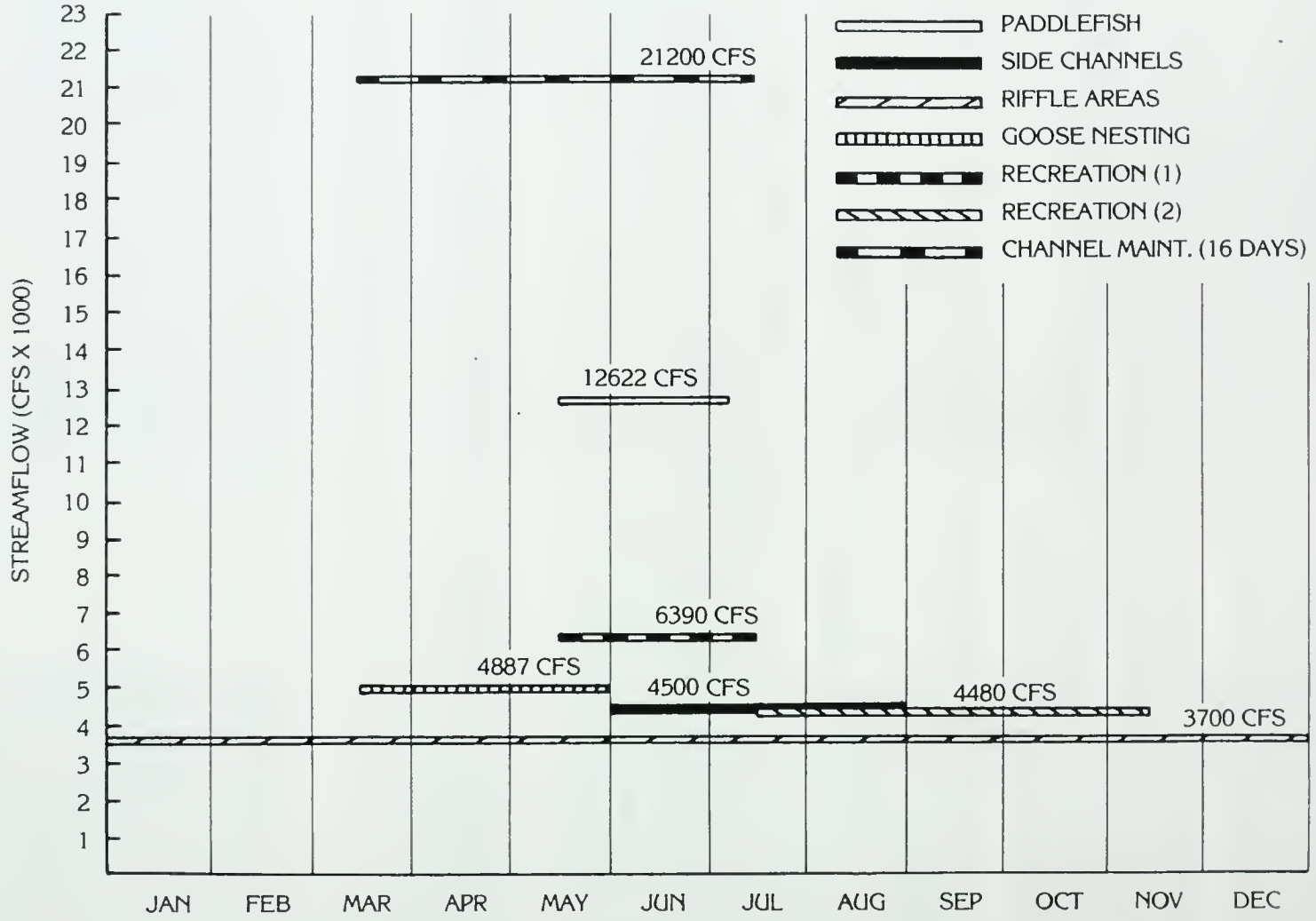

FIG. 3 HYDROGRAPH OF ALL RECOMMENDED INSTREAM FLOW NEEDS AT FORT BENTON

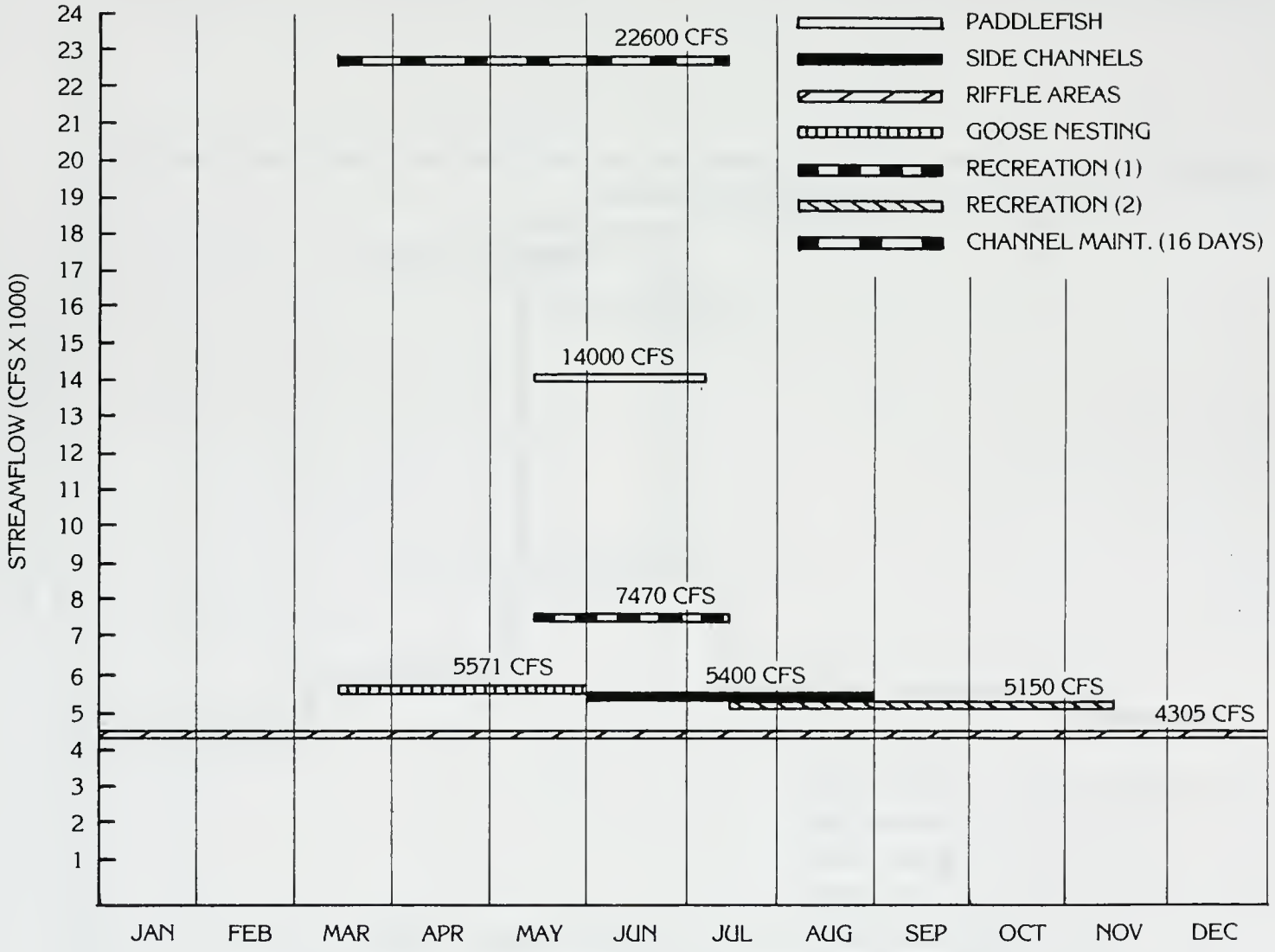

FIG. 4 HYDROGRAPH OF ALL RECOMMENDED INSTREAM FLOW NEEDS AT VIRGELLE

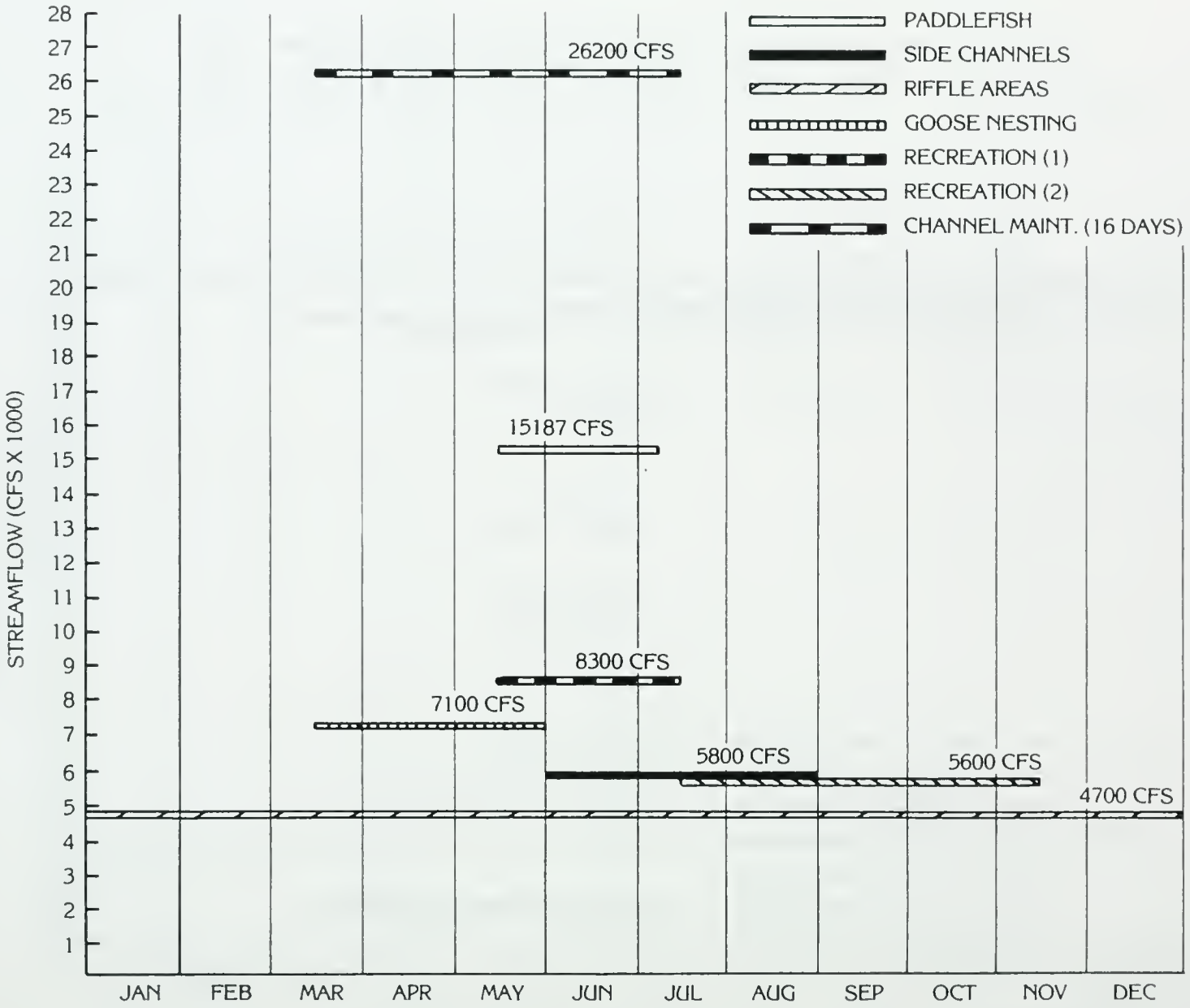

FIG. 5 HYDROGRAPH OF ALL RECOMMENDED INSTREAM FLOW NEEDS AT FRED ROBINSON BRIDGE

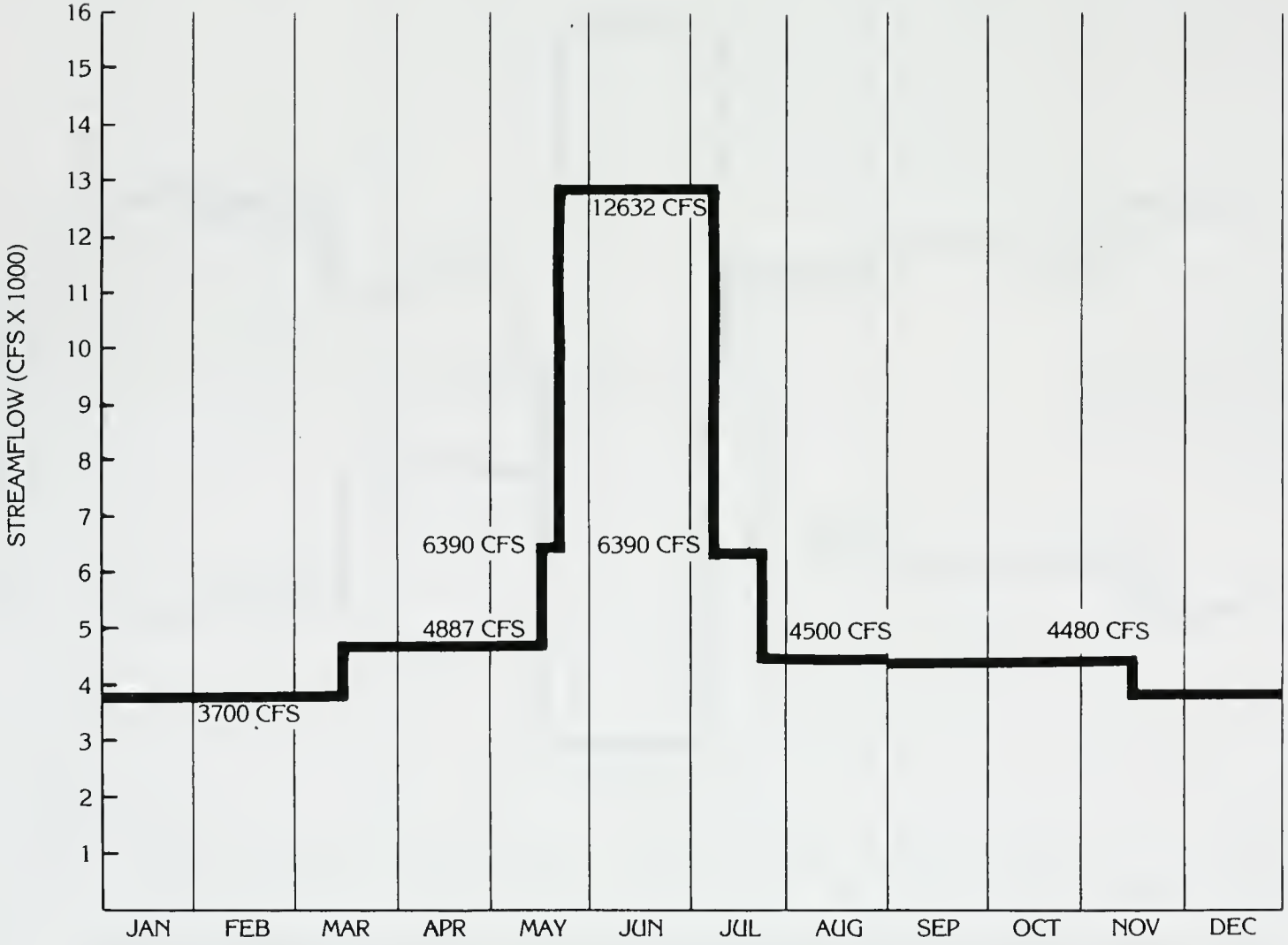

FIG. 6 COMPOSITE HYDROGRAPH OF RECOMMENDED INSTREAM FLOW NEEDS AT FORT BENTON
Channel Stability Streamflows of 21,200 CFS (required 16 days/yr ave) not shown

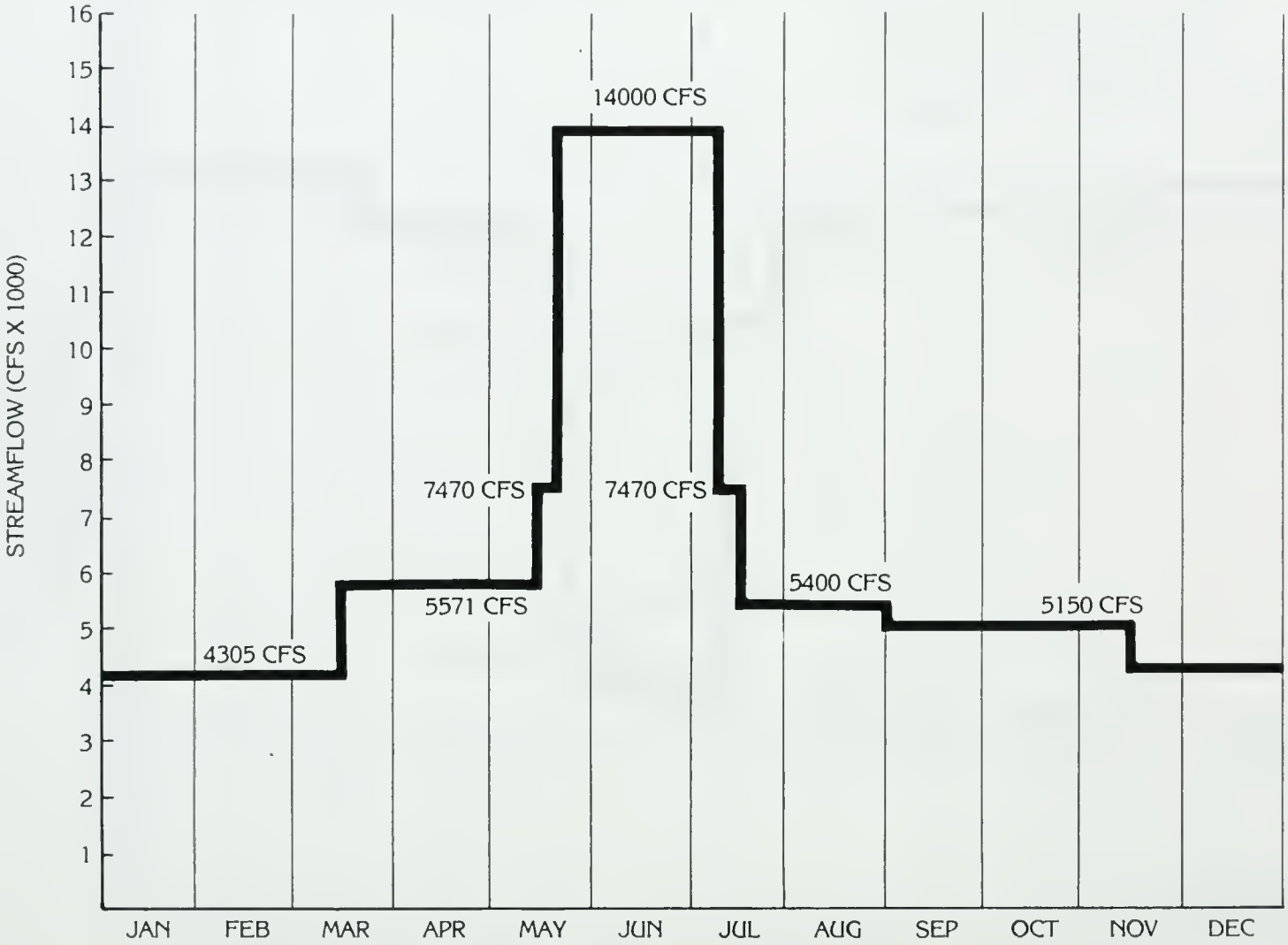

FIG. 7 COMPOSITE HYDROGRAPH OF RECOMMENDED INSTREAM FLOW NEEDS AT VIRGELLE
Channel Stability Streamflows of 21,200 CFS (required 16 days/yr ave) not shown

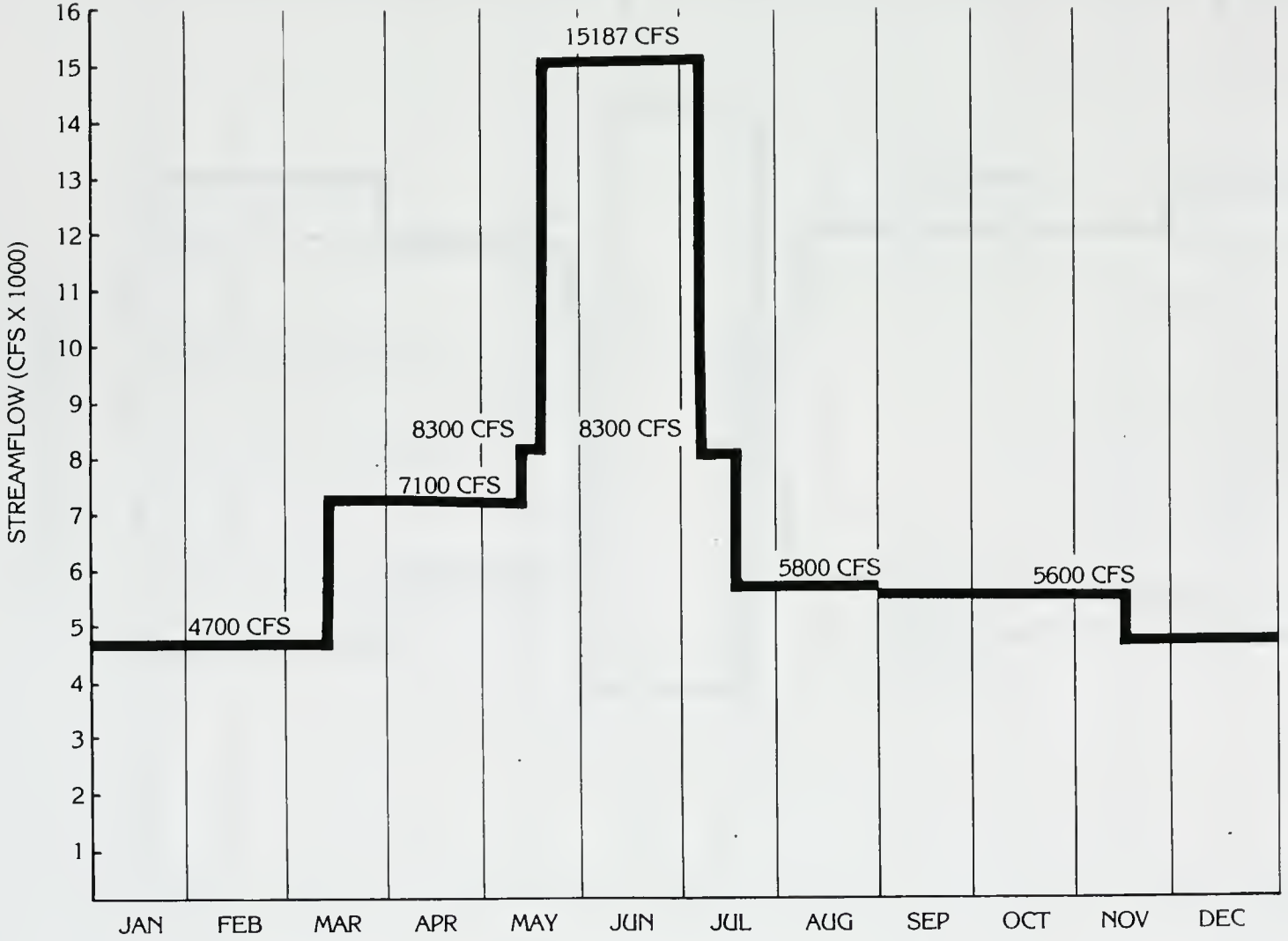

FIG. 8 COMPOSITE HYDROGRAPH OF RECOMMENDED INSTREAM FLOW NEEDS AT FRED ROBINSON BRIDGE
Channel Stability Streamflows of 21,200 CFS (required 16 days/yr ave) not shown

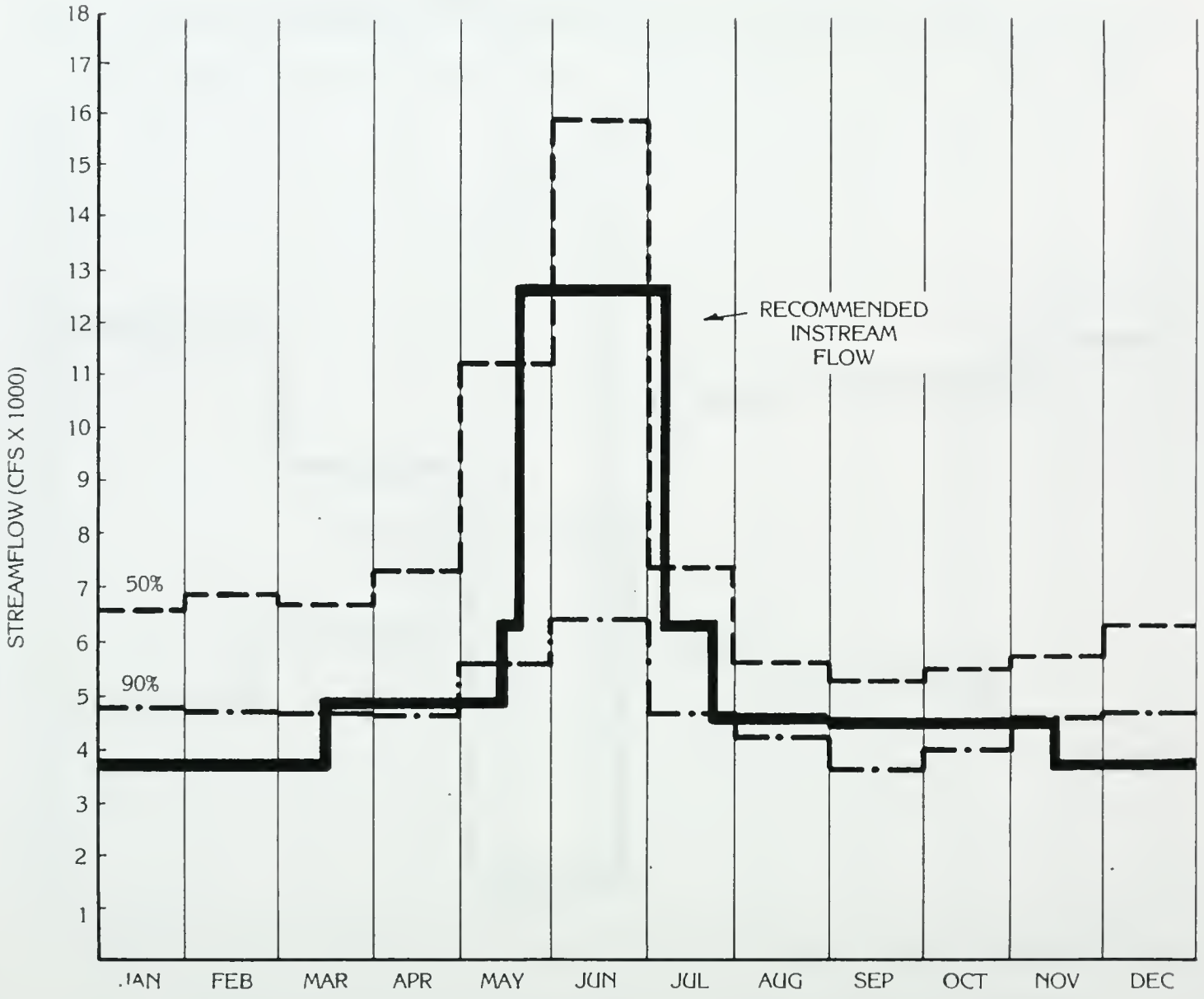

Fig. 9 THE STREAMFLOWS (1953—1982) WHICH ARE EQUALLED OR EXCEEDED EITHER 50 OR 90 PERCENT OF THE TIME AND THE RECOMMENDED INSTREAM FLOW AT FORT BENTON

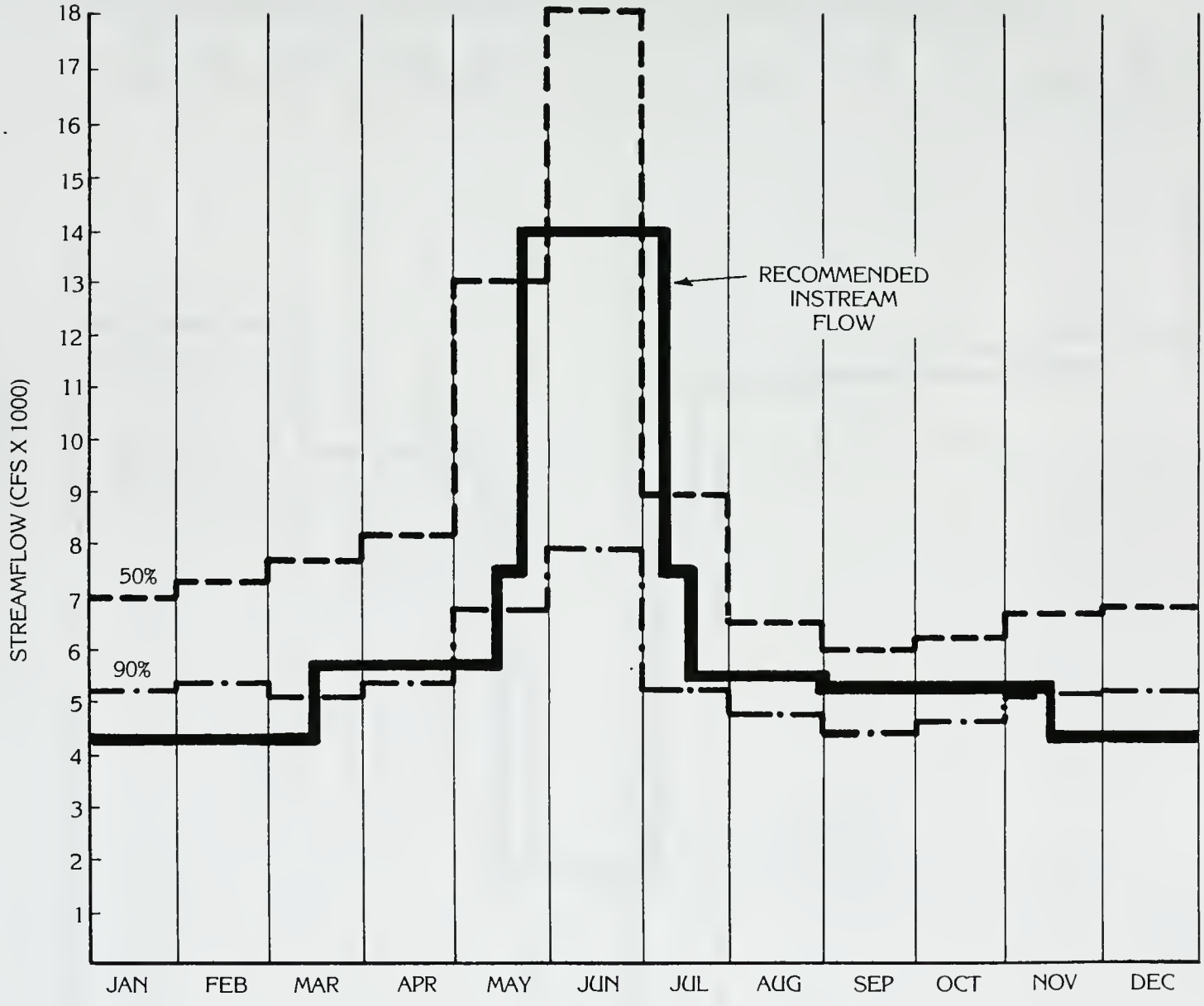

Fig. 10 THE STREAMFLOWS (1953—1982) WHICH ARE EQUALLED OR EXCEEDED EITHER 50 OR 90 PERCENT OF THE TIME AND THE RECOMMENDED INSTREAM FLOW AT VIRGELLE

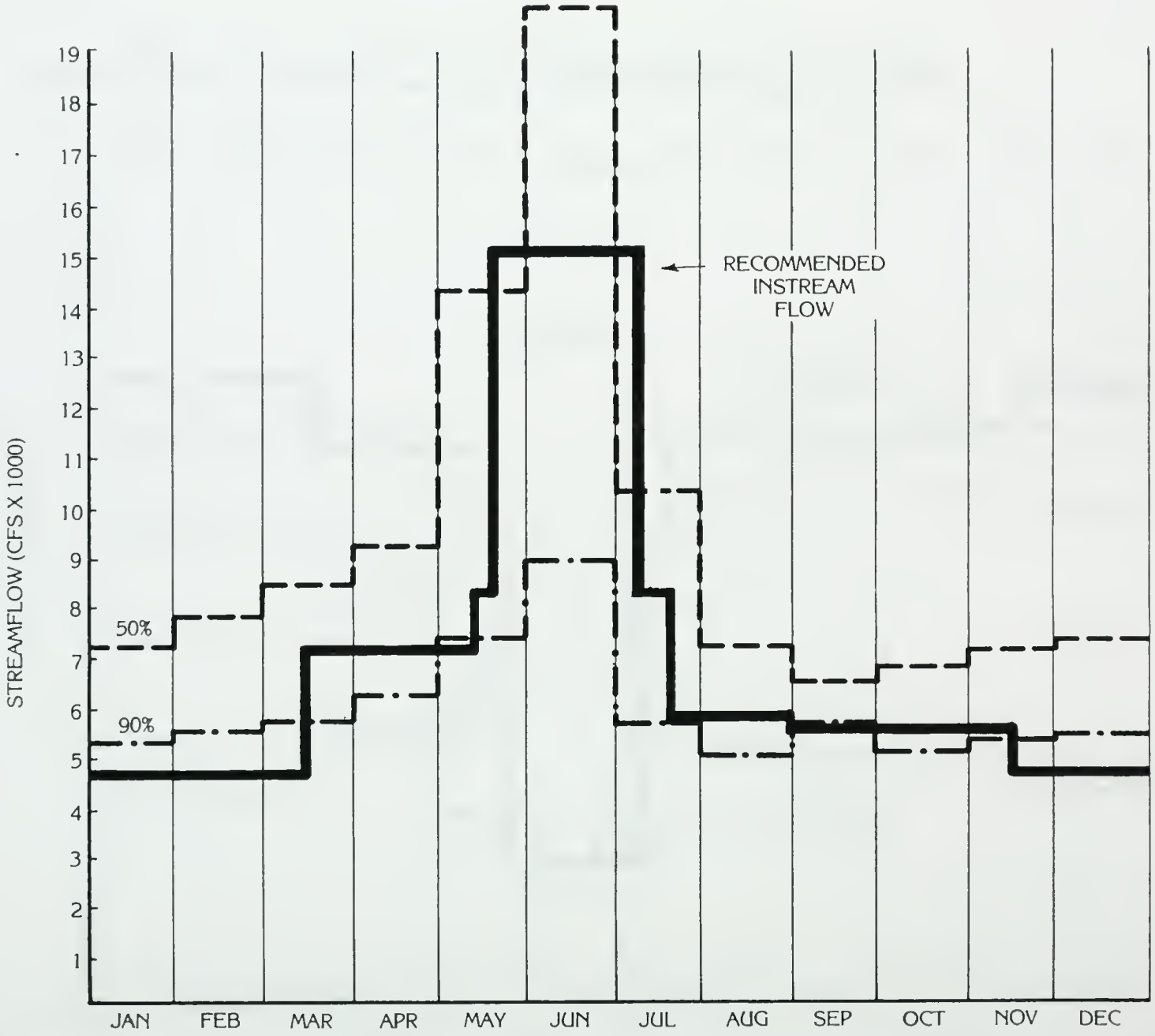

Fig. 11 THE STREAMFLOWS (1953—1982) WHICH ARE EQUALLED OR EXCEEDED EITHER 50 OR 90 PERCENT OF THE TIME AND THE RECOMMENDED INSTREAM FLOW AT FRED ROBINSON BRIDGE

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APPENDIX B

Methodology Manual

For Conservation District Water Reservation Applications

December 1991

METHODOLOGY MANUAL
FOR
CONSERVATION DISTRICTS WATER RESERVATION APPLICATIONS

DECEMBER, 1991

Department of Natural Resources and Conservation
Water Resources Division
1520 East Sixth Avenue
Helena, MT 59620-2301

TABLE OF CONTENTS

Page

INTRODUCTION 4
Background 4
Purpose 4
Process Overview 4

PROJECT IDENTIFICATION 5
Operator Interest Survey 5
DNRC-Identified Projects 5
SCS-Identified Projects 6

SURFACE WATER AVAILABILITY 7
Streamflows 7
Irrigation Demands 7
Storage Projects 8

WATER QUALITY 9
Water Quality Data 9
Water Quality Criteria 9
Water Quality Evaluation 9

GROUNDWATER AVAILABILITY 10

SOILS 12
Land Classification 12
Field Procedures 15
Design Recommendations 15

FIELD INSPECTION 18
Operator Interest Projects 18
DNRC- and SCS-Identified Projects 19

IRRIGATION DESIGN, AND ECONOMIC AND FINANCIAL EVALUATION 20
Irrigation Systems Design 20
Economic Evaluation 26
Choice of Crop and Farm Operation 27
Peak Yield Estimate 27
Annual Production 30
Cost of Production 32
Price Forecast 35
The Precipitation Equation 37
The Calf Price Equation 42
The Hay Quantity Equation 43
Discount Rate 43
Planning Period and Number of Scenarios 43
Net Revenue 43

REFERENCES 45

APPENDICES

APPENDIX A: Methodology Review by Aquoneering A-1
APPENDIX B: Operator Interest Survey Information B-1
APPENDIX C: Synth Program and Methods Used to Estimate Crop Irrigation Requirements C-1
APPENDIX D: Water Quality Criteria D-1
APPENDIX E: Forms Used During Field Investigations E-1

LIST OF TABLES

Table 1. Land Classification Criteria 13
Table 2. Example of Irrigation Costs Table from IDA Spreadsheet 25
Table 3. Regression Equation and Linear Coefficients Used to Determine Peak Attainable Yield from Total Evapotranspiration 29
Table 4. Peak Attainable Alfalfa Yield for 17 Stations in the Missouri Basin 29
Table 5. Farm-Attainable Alfalfa Yield for Selected Weather Stations 31
Table 6. Distribution of Rotation Length Producing the Highest Net Present Value (NPV) for 120 Forecasts 31
Table 7. Crop Production Costs at Various Yields 33
Table 8. Machinery Use Spreadsheet Input Sheet and Summary 34
Table 9. System Variables for the Enterprise Analysis Spreadsheet 35
Table 10. Alfalfa Price Equation 36
Table 11. Autoregressive Alfalfa Price Equation 37
Table 12. Precipitation Equation 38
Table 13. Wheat Price Equation 39
Table 14. Barley Price Equation 40
Table 15. Oats Price Equation 41
Table 16. Calf Price Equation 42
Table 17. Hay Production Equation 43

LIST OF FIGURES

Figure 1. An example of an irrigation system design and project area soil map 16
Figure 2. Attributed blocks used in the irrigation design process. 21
Figure 3. Legend for AutoCAD irrigation design 23
Figure 4. An example of an AutoCAD irrigation design 24
Figure 5. Linear relationship of yield in relation to ET for alfalfa 28
Figure 6. Alfalfa yields with age of stand 30

INTRODUCTION

Background

In 1985, the Montana Legislature directed the Department of Natural Resources and Conservation (DNRC) to begin a water reservation proceeding for Montana's Missouri River basin. The proceeding allowed public entities to apply to reserve water for future consumptive water use and instream uses (Section 85-2-331, MCA). DNRC was given the responsibility of preparing water reservation applications for municipalities and conservation districts (CDs) interested in reserving water. This manual describes DNRC's methods for preparing conservation district water reservation applications.

The reservation proceeding schedule divided the Missouri River basin into three major sections. In 1985, the legislature provided funding to prepare water reservation applications for conservation districts in the basin above Canyon Ferry Dam. These applications were completed by HKM Associates (an engineering firm) of Billings under contract and in cooperation with DNRC. The 1987 legislature provided funding to prepare water reservation applications for conservation district in the basin between Canyon Ferry and Fort Peck Dam. DNRC staff prepared these applications. The 1989 legislature provided funding to prepare applications for the final section of the basin, from Fort Peck Dam to the state line and including the Little Missouri River basin. DNRC staff also prepared these applications.

The Board of Natural Resources and Conservation must make a final decision on all applications to reserve water above Fort Peck Dam by July 1, 1992. Those applications to reserve water below Fort Peck Dam and in the Little Missouri basin must be decided on by December 31, 1993.

Purpose

The purpose of this manual is to describe the methods developed and used in completing water reservation applications for conservation districts in the Missouri River basin. DNRC is required both to prepare CD reservation applications and to review them to determine whether they are correct and complete. To ensure objectivity in the process, DNRC hired Aquoneering of Laurel, Montana, to provide an independent technical review of DNRC's work. Aquoneering commented on the quality of the information and methods used in preparing CD reservation applications. Aquoneering's findings are presented in the report: A Methodology Review: Water Reservation Applications, Middle Missouri River Conservation Districts (Aquoneering 1988). A copy of this report is included as Appendix A.

Process Overview

In preparing water reservation applications for conservation districts, DNRC first identified potential irrigation projects. Procedures were then used in the office to determine if surface water or groundwater of suitable quality was available for these projects and if project soils were suitable for irrigation. Field inspections were conducted for projects still under consideration to verify conclusions made in the office and to collect additional information. Finally, computer programs were used to design the irrigation projects and evaluate them from a economic and financial perspective. The rest of this document contains more detailed explanations of these evaluation procedures.

PROJECT IDENTIFICATION

Land for inclusion in the application was identified using the following three basic sources of information: (1) an operator interest survey sent by each conservation district, (2) the irrigable lands study conducted by DNRC, and (3) the irrigable lands study conducted by the U.S. Soil Conservation Service (SCS).

Operator Interest Survey

The first step in identifying potential projects in each CD was to survey its farm and ranch operators. A comprehensive mailing list for operators in the basin in each county was obtained from the Statistical Reporting Service of the Montana Department of Agriculture. The first mailing contained a cover letter from an official in the CD, a fact sheet describing the water reservation proceedings, and a short questionnaire. The purpose of the mailing was to obtain information on the nature and location of potentially irrigable lands, and water sources that could be used to irrigate them. Sample copies of the cover letter, fact sheet, and first questionnaire are provided in Appendix B.

DNRC established a project file for each positive response to the first questionnaire. Each file contained the response to the first questionnaire and copies of topographic maps and aerial photos of the project area(s) identified by the operator.

A second mailing was sent to operators who responded positively to the first questionnaire. This mailing contained a second questionnaire, project area maps and photos, and an example map. The second questionnaire requested specific information about the proposed water source, any previous water shortages, intended crops, irrigation systems, and development schedules. The operator also was asked to delineate the area intended to be irrigated and the proposed irrigation system on the enclosed project area map. The example map showed the operator how the water source and irrigated land should be delineated. Sample copies of the cover letter, second questionnaire, and example map are contained in Appendix B.

A third mailing containing a reminder letter was sent to individuals who did not respond to the second questionnaire. The conservation district offices also were asked to contact persons who did not respond to the second mailing. These reminders helped to generate additional responses.

Responses to the second questionnaire and the accompanying maps and photos were included in the landowner project files. Copies of available soil maps and extra copies of topographic maps and photos also were placed in the files along with a landowner status sheet. The status sheet was used to track each project through the screening process. A copy is provided in Appendix B.

A computer data base also was established to record the number of positive and negative responses to the first questionnaire and track the progress of each project throughout the screening process. The data base was updated with information obtained from both questionnaires regarding project location, soil suitability, water availability, field investigations, and project feasibility. The data base also was used to produce summary reports on the landowner interest survey, which were included in each water reservation application.

DNRC-Identified Projects

DNRC developed an irrigable lands assessment method (ILAM) to identify land that could be

irrigated along major streams in the basin by individual farmers. The purpose of ILAM was to document Montana's current and future water needs in preparation for an eventual interstate water allocation procedure in the basin. ILAM uses data on economic, topographic, soil, climatic, agricultural, engineering, and hydrologic conditions to predict the feasibility of sprinkler irrigation development. A complete description of ILAM is contained in a DNRC document entitled, "Identification of Irrigable Lands in the Missouri Basin of Montana" (DNRC 1987). A brief description of ILAM is as follows.

Sprinkler irrigation feasibility corridors were delineated by DNRC along major water sources based upon economical pumping lifts and distances from river channels. Maximum lift and distance corridors were plotted on U.S. Geological Survey (USGS) topographic maps at scales of 1:24,000 or 1:62,500. The DNRC irrigated lands inventory (DNRC 1987) and published Montana Water Resources Surveys (DNRC 1946-72) were used to subtract past and present irrigated acres from the corridors. The best available soil mapping in each county was used to identify suitable soils within the corridors.

DNRC conducted reconnaissance field investigations of ILAM project areas to better define project boundaries and locate points of diversion. Files for ILAM projects contained topographic maps, soil maps, and irrigation design layouts. Where overlap occurred between ILAM projects and landowner interest projects, the latter were subtracted from the design areas.

The landowners within each ILAM project area were identified by consulting the plat maps available at the appropriate county assessor's office. A cover letter and questionnaire were sent to all landowners to assess their interest in including their land as part of their district's water reservation application. Lands were dropped from the projects at the owner's request.

SCS-Identified Projects

In the 1970s, SCS in cooperation with DNRC conducted a study that identified and evaluated potential irrigation projects greater than 1,000 acres. The study is described in Summary Report, Upper Missouri River Basin Cooperative Special Study, Montana (USDA undated). The projects were identified through a screening process that assessed soil suitability, legal water availability, storage site potential, and water quality. Irrigation delivery system costs, engineering costs, project administration costs, and operation and maintenance costs were compared with yield information and crop prices to produce a benefit-cost ratio for each project. A field inspection of pumping plant and dam site locations and cropping patterns completed the process for identifying feasible projects.

DNRC established files and applied DNRC screening and design methods to SCS projects with a benefit-cost ratio of 0.60 or greater. Projects with benefit-cost ratios less than 0.60 were deemed infeasible. Landowner interest and ILAM project areas were subtracted from the SCS project areas when overlap occurred. DNRC and SCS-identified projects were included in CD applications upon approval of the CD board of supervisors.

DNRC evaluated each irrigation project to determine whether the proposed water source could supply the estimated demands. The evaluation of water supply was based on physical rather than legal water availability. This approach was taken because water rights claims and permits often do not reflect the real amount of water diverted and also fail to account for irrigation return flows and subsequent water reuse.

Streamflows

Monthly average and percentile streamflow statistics were obtained from the USGS for gaging stations throughout the Missouri River basin (USGS 1981, 1988). If the proposed source stream was gaged, the monthly 80th percentile streamflows (the 80th percentile streamflow is the monthly flow that is equalled or exceeded 8 years out of 10) were compared to the estimated monthly irrigation demands. If the 80th percentile streamflows were greater than or equal to the estimated monthly irrigation demands, water was assumed to be physically available for the project. If the proposed irrigation demands exceeded the available streamflows, DNRC estimated the irrigation potential of the stream was made and in some instances reduced projects until the irrigation needs could be met with the available flows.

If the proposed source stream was ungaged, monthly average and percentile streamflows were estimated with a computer program called SYNTH. The SYNTH program uses a lag-one Markov model to synthesize 50 years of monthly streamflows and then performs a frequency analysis to compute the estimated monthly average and percentile flows for the ungaged site. This program is a modification of the Markov and frequency analysis portions of the Holnbeck reservoir yield program described later in this section. The SYNTH program input requirements include average annual flow at the point of diversion, standard deviation of the average annual flow, and monthly flow distribution. A printout of this program, along with sample input and output files, is included in Appendix C.

Several regional equations are available for estimating the average annual runoff of an ungaged basin as a function of the basin's drainage area and average annual precipitation (Potts 1983, Omang and Parrett 1984, Parrett and Hull 1985). The Omang and Parrett equation was most frequently used in this analysis. Drainage areas for the proposed points of diversion were delineated and measured from USGS topographic maps. Average annual precipitation was estimated from SCS isohyetal maps (USDA 1980). Field notes were consulted to account for any additional site-specific factors that might influence streamflows at the proposed point of diversion. The standard deviation and monthly distribution of the average annual runoff were estimated from streamflow statistics recorded at one or more gaged stream sites with drainage basin characteristics similar to those of the ungaged site (USGS 1981). The computed parameters were adjusted as necessary to reflect any local conditions noted during the field observations. Once the monthly percentile streamflows were estimated with the SYNTH program, surface water availability was determined in the manner described for gaged sites.

Irrigation Demands

Irrigation demands were computed by multiplying the proposed number of irrigated acres by the net crop irrigation requirement, and then dividing this total by the overall irrigation efficiency of the proposed system. For the purposes of this initial screening process, irrigation demands were calculated assuming the proposed projects would consist of a pipeline-to-sprinkler irrigation system irrigating a crop of alfalfa in a dry year. Results of this analysis are presented in Appendix C.

The per-acre monthly net crop irrigation requirements (NCIR) for alfalfa were computed using the Soil Conservation Service MT_TR-21 computer program (USDA 1988) with local weather station data. This program contains a Blaney-Criddle evapotranspiration model that has been adjusted for elevation.

Storage Projects

If an irrigation project included building new storage facilities, the proposed reservoir site was evaluated using the Reservoir Yield Simulation Model. A detailed discussion of this model is presented in Holnbeck 1985 and is only briefly described here.

The reservoir yield program was used to determine the smallest reservoir required to supply the requested monthly yield with 100 percent reliability. If the stored streamflow could not meet irrigation demands, the proposed irrigated acreage was scaled down until 100 percent reliability could be met. The program input requirements include average annual runoff, standard deviation of annual runoff, monthly streamflow distribution, maximum dam height, maximum reservoir capacity, and monthly reservoir evaporation.

Reservoir inflows were computed by the program using a lag-one Markov model. Inflows for July, August, and September were set equal to zero under the assumption that, if water must be stored to meet new irrigation demands, little water is available at present during those months. Reservoir capacity and dam height were determined from field observations and measurements made from topographic maps. Monthly reservoir evaporation data were obtained from monthly evaporation maps developed from Weather Bureau records (Minnesota Resources Commission 1942).

WATER QUALITY

The water quality of each proposed source stream was evaluated to determine whether it was suitable for irrigation.

Water Quality Data

USGS has fragmented water quality data for some of the gaging stations on the major waterways of the state (USGS 1980 - 1987). The Montana Department of Health and Environmental Sciences (DHES) also has collected water quality data from numerous streams throughout the basin but does not maintain any long-term continuous monitoring stations. However, DHES has made extensive efforts to assess all available data and identify the stream reaches in the state where beneficial water uses could be impaired by water quality (DHES 1986).

Assessment of water quality at a source stream was difficult due to both the lack of long-term data and the fact that stream water quality tends to be highly correlated with seasonal flow fluctuations. For example, a sample collected during the spring or after a storm when streamflows are high will show large sediment loads, whereas data taken during a low flow period will tend to show lower sediments but higher concentrations of dissolved materials.

Water Quality Criteria

Water quality for irrigation was evaluated based on total dissolved solids (TDS), sodium adsorption ratio (SAR), electrical conductivity (EC_w) to evaluate the level of salts, and specific concentrations of various ions and metals. Water quality guidelines of DHES were used to assess the suitability of proposed source streams for irrigation.

DHES has prepared a list of irrigation water use standards for 19 pollutants that affect water quality in Montana (DHES 1986). These guidelines have been adapted from those developed by the U.S. Environmental Protection Agency (EPA), Region VIII. A committee of consultants from the University of California also has prepared a set of irrigation water quality criteria which is a combination of several sets of guidelines adapted to field conditions (FAO 1985) (Table D-1, Appendix D). These criteria place a degree of restriction on irrigation water use based on nine different water quality parameters. A final set of irrigation water criteria (Table D-2) developed by the National Academy of Sciences was used to assess potential trace metal toxicity problems (NAS 1972). These metals are a special concern in streams that might carry acid mine drainage.

Water quality also was checked to see if new irrigation development would be detrimental to aquatic life. Water quality data were compared to guidelines established by EPA and DHES for numerous constituents including trace metals. In most cases, however, it was assumed that the new irrigation projects would have little impact on existing water quality because of the efficient pipelines-to-sprinkler irrigation designs and the low soil salinity of project lands.

Water Quality Evaluation

Where available, USGS and DHES monitoring data (USGS 1980 -1987, DHES 1974) were compared to water quality standards for irrigation use and freshwater aquatic life. If the data indicated marginal-to-good water quality for irrigation, the project was retained in the reservation process. If the data indicated any severe restrictions to irrigation water use, the project was screened out.

GROUNDWATER AVAILABILITY

If the applicant expressed an interest in reserving groundwater, a procedure was applied to determine groundwater availability. The first step of this procedure was to identify any aquifers underlying the project site, using published and unpublished hydrogeologic and geologic maps. The sources of such information included:

1. U. S. Geological Survey geological maps at a variety of scales, typically published as part of the following series:

   - Geologic quadrangles (GQ series)
   - Hydrologic atlases (HA series)
   - Miscellaneous investigations (I series)
   - Bulletins
   - Water Resources Investigations (WRI series)

2. Montana Bureau of Mines and Geology (MBMG) maps at a variety of scales, typically published as part of the following series:

   - MBMG Bulletins
   - MBMG Memoirs
   - MBMG Atlases
   - MBMG Geologic Maps
   - MBMG Open-File Reports

3. Unpublished geologic maps, typically from graduate theses or other academic projects

The USGS and MBMG materials receive extensive pre-publication review (with the exception of open-file reports) and are considered to be dependable sources of basic geologic information. Academic projects are of more variable quality and were used only when the DNRC geologists were satisfied with their conclusions.

Once the potential aquifers were identified, water chemistry data for each were assembled. The sources of these data may have included all of those listed above, plus MBMG open-file mapping of regional groundwater chemistry and water-quality data bases maintained by USGS and by the MBMG groundwater information center (GWIC). The USGS and GWIC data bases are subject to considerable internal review and are considered dependable and accurate. However, few data points may exist in some areas, leaving considerable gaps between points of known water chemistry.

If the information available suggested that no aquifer underlying the project contains water of suitable quality, groundwater was rejected as a water supply option for the project. The criteria used were based on "Irrigation Water Quality in Montana" (Schafer 1983). Total dissolved solids in excess of 2,500 mg/l or an adjusted sodium adsorption ratio in excess of 15 disqualified the aquifer from further consideration.

If the chemical characteristics of groundwater supplies appeared to be acceptable, the next step was to assess potential well yields from the aquifer. Information on well yields was derived from the same sources listed above, with the addition of DNRC appropriations records for the area of interest. This body of information is inherently more uncertain than the water quality data employed in the first screening step, due to factors such as variable well construction, variable intensity of exploration, and aquifer heterogeneity. In recognition of this fact, projects were given the benefit of any doubt regarding

well yields from a particular aquifer. If known well yields in the area were in the range of the calculated peak water requirements of the proposed project, or if geologic inference suggested that such yields might be available, the project was retained for the next screening step. If all available aquifers are believed to be clearly incapable of supplying the required flow rates, groundwater was rejected as a water supply option for the project.

Projects remaining in consideration for groundwater reservations were then assessed with regard to the aquifer's state of appropriation. Since the State of Montana has no systematic means of assessing the level of development of aquifers, this step was envisioned as a somewhat subjective process based on DNRC records of groundwater development and the presence or absence of water availability problems.

Any proposed projects that remained under consideration were then screened for the economic feasibility of well drilling and groundwater use. Probable well-drilling depths were determined from interpretations of the geologic mapping cited earlier. Matrices incorporating drilling depth, per foot cost of hole, estimated pumping head, interest, and amortization rates were used to establish a maximum feasible drilling depth for the proposed reservation. Unit costs for well drilling were derived from a survey of selected eastern and central Montana water well contractors, and appropriate economic variables selected by DNRC. The projects were given the benefit of doubt throughout this process, so the maximum feasible well depth arrived at was a generous one.

If the minimum drilling depth determined from geologic mapping and description exceeded the maximum feasible depth determined from the cost matrix, groundwater was rejected as a water-supply option. The remaining projects were retained as feasible and passed on to the next screening step.

The soils investigation ensured that only arable lands were included in proposed irrigation projects. By definition, arable land must have the proper soils, climate, and topography to sustain irrigated agriculture. The soil screening procedure combined soil survey data, land classification criteria, and field observations to recommend that land be either included in or excluded from an irrigation project. Irrigation design parameters were then estimated for each suitable soil type and used in determining the amount of water required for crop production.

Land Classification

DNRC uses a reconnaissance land classification system to identify suitable soils based on physical and chemical properties. The classification criteria, listed in Table 1, were developed from U.S. Bureau of Reclamation (BUREC) and Soil Conservation Service (SCS) guidelines. Arable lands are divided into three classes, with Class 1 land having the highest productivity potential and fewest limitations. Class 2 and Class 3 lands are of progressively lower quality. Lands that do not meet the criteria are labeled Class 6. A fifth category, labeled "6i," identified class 6 soils that were determined to be suitable after a field investigation.

Where SCS soil mapping was current, the criteria in Table 1 were used to classify soils to DNRC's system. The ratings were based on a comparison of the classification criteria with information from soil interpretive records. Any single deficiency below the criteria for a class was cause for downgrading the map unit to the next lower class. Two or more deficiencies lowered the rating by two classes if their effects were additive. Combinations of less severe deficiencies were evaluated on a judgment basis. The map unit ratings were reviewed by SCS soil interpretation specialists, and their suggestions were incorporated into the final designations.

Lands previously classified and mapped according to the DNRC system based on older soil surveys are delineated on township plat maps at a scale of 1:32,000 for each Montana county. These maps were used to evaluate land not covered by current SCS soil survey mapping.

Project areas not covered by SCS soil survey mapping or DNRC land class mapping were evaluated by examining other sources of information. These sources included Agricultural Stabilization and Conservation Service (ASCS) aerial photos, USGS topographic and geologic maps, soil surveys for farm planning, and SCS soil surveys of similar or adjacent areas. These maps and photos identified limitations such as steep slopes and evidence of salinity or alkalinity. They were used to produce a preliminary project area map containing land classification units.

Land classification maps, whether based on SCS surveys, DNRC surveys, or a combination of geographic information, were further refined during a field investigation. Soil factors such as depth, texture, structure, and drainage were more closely examined in the field.

Table 1. Land Classification Criteria

Soil or Land Characteristics	Class 1 Slight Limitations	Class 2 Moderate Limitations	Class 3 Severe Limitations
Dominant texture of root zone	Fine sandy loam to friable clay loam	Loamy sand to permeable clay	Loamy sand to clay
Depth to clean sand, gravel, and cobble	40" minimum	20" minimum	10" minimum
Depth to hard rock, sand-stone, or non-saline shale	60" minimum	40" minimum	30" minimum
Volume of tillage layer	No problem in tillage	Moderate problem in tillage	Severe problem in tillage
Gravel (<3") Cobble (3" to 10")	Up to 15% gravel	15% to 50% gravel 3" up to 15% cobble	Over 50% gravel 15% to 50% cobble
Stoniness of surface and tillage layer; stones generally greater than 12" in diameter	No problem in tillage	Cultivation not impractical. Stones over 12" diameter occupy 0.01% to 0.1% of the surface.	Cultivation impractical unless cleared. Stones over 12" diameter occupy 0.1% to 3% of the surface.
Rockiness (small outcrops within soil type)	No problem in tillage. Up to 2% of surface may have bedrock exposed.	2% of surface may have bedrock exposed.	2% to 10% of surface may have bedrock exposed.

Land Classification Criteria (continued)

Soil or Land Characteristics	Class 1 Slight Limitations	Class 2 Moderate Limitations	Class 3 Severe Limitations
Available water-holding capacity (to a maximum depth of 48")	Over 6"	4" to 6"	2" to 4"
Permeability	Moderately slow (.20"/hr) to moderate (-2"/hr)	Slow (.06"/hr) to moderately rapid (2" to 6.30"/hr)	Very slow (up to .06"/hr) to rapid (over 6.30"/hr)
Salinity or alkalinity	Electrical conductivity not to exceed 4 millimhos/cm. May be higher under good leaching and drainage conditions, but not to exceed 8 millimhos/cm in top 4 ft.	Electrical conductivity not to exceed 8 millimhos/cm, except with good leaching and drainage. Most horizons will have up to 8 millimhos/cm.	Electrical conductivity not to exceed 8 millimhos/cm in top 2 ft. Lower horizons may be higher under good leaching and drainage conditions, but not to exceed 15 millimhos/cm.
Slope	0 to 4%	4% to 8%	8% to 15% (Sprinkler irrigation on slopes (over 8%)
Water table	Easily maintained below 60" depth during growing season	Practical to maintain below 40" depth most of the growing season (requires drainage)	Can maintain below 20" most of the growing season
Overflow	No overflow	Free of overflow in growing season	Overflow may be hazard to crops in some years (2 or 3 in 10)

Land Classification Criteria (continued)

Soil or Land Characteristics	Class 1 Slight Limitations	Class 2 Moderate Limitations	Class 3 Severe Limitations
Climate	Growing season over 90 days	Growing season over 90 days	Growing season may be less than 90 days

Field Procedures

DNRC conducted a field investigation for each project not screened out in the preliminary stages. Field traverses and bucket auger boring were used to survey the proposed project areas and describe individual soils.

Soil salinity was determined. Without careful management, irrigation of saline soils can increase discharges to potential seep areas. The geology of the region, high precipitation periods, and farming practices all contribute to an expanding salinity problem (Brown et al 1982).

Areas affected by alkalinity also were identified. The clayey textures, smectite mineralogy, and high levels of exchangeable sodium in glacial tills and marine shales typically produce a mosaic of barren, shallow depressions of alkaline soils across much of Montana's Missouri basin landscape. The very slow water intake rate of alkaline soils leaves applied irrigation water susceptible to runoff and evaporation. The cultivation and irrigation of alkaline soils commonly are inhibited by inadequate drainage, inadequate supply of good-quality leaching water, and cost and availability of calcium sources to replace adsorbed sodium (Bresler et al 1982).

The field investigations screened saline and alkaline soils from irrigation project areas. Other Class 6 soils were generally excluded from design areas if they exceeded 10 percent of the total project. In some cases, Class 6i soils that exceeded 10 percent of the project area remained in the project if field observations indicated they were suitable for irrigation. The final product of the soils investigations was a map at a scale of 1:24,000 containing land classifications. An example is shown in Figure 1.

Design Recommendations

The soil investigations were used to recommend that land parcels be included in or excluded from a project. Specific soil characteristics necessary for irrigation design were then estimated for each soil map unit. The water intake rate and the available water capacity (AWC) are two parameters needed for the principal soils being irrigated. The Montana Irrigation Guide (USDA, 1987) contains an appendix of these design values for over 450 Montana soil series. The guide also contains guidelines for estimating sprinkler intake rates and AWC based on soil properties.

When the series-specific characteristics did not correspond to soil map units, the published guidelines were combined with field observations to estimate intake rate and AWC. For example, the guidelines recommend an intake rate of 0.5 in/hr for clay loam soils. This rate was increased or decreased depending upon a number of modifying conditions observed in the field such as vegetative cover, surface crusting, and salt accumulation. In another example, the guidelines recommend an AWC value of 2.2 in/ft for a clay loam. This was adjusted upward or downward corresponding to conditions such as rock content, salt content, and soil structure.

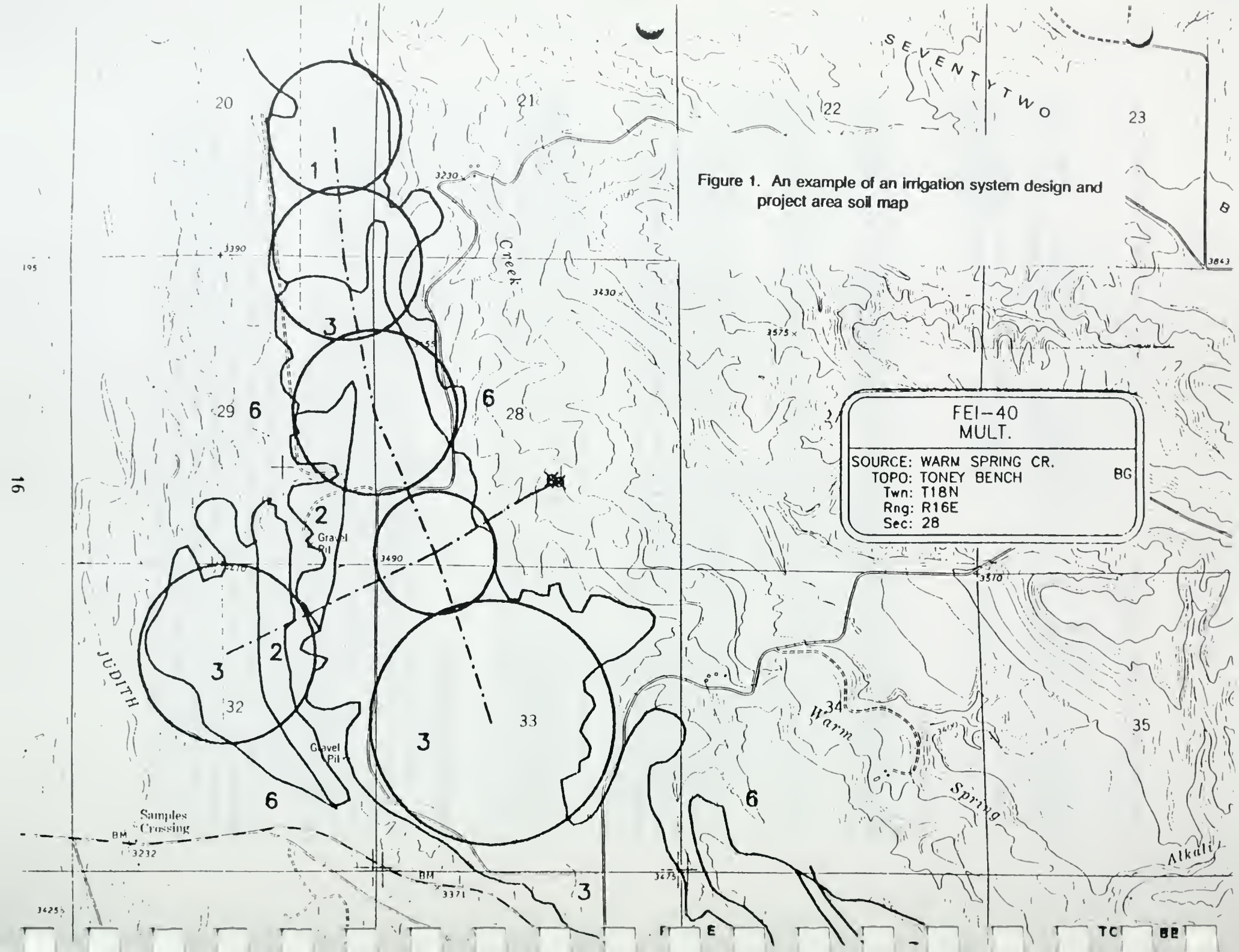


Figure 1. An example of an irrigation system design and project area soil map

Once values for intake rate and AWC were estimated, the project was ready for an irrigation system design. Because the methodology used to identify the projects provided only reconnaissance level information, more detailed investigation should be conducted prior to development. This investigation should include laboratory analysis for sodium adsorption ratio (SAR), settling volume, and particle size distribution. Drainage and infiltration testing are recommended where these parameters may be limiting.

FIELD INSPECTION

When analysis in the office determined that a project had available water and suitable soils, it was further examined in the field to record details about the proposed water source, conveyance route, and land proposed for irrigation. The field inspection also was used to record likely impacts to cultural and biological resources. More detailed investigations were conducted for the landowner-identified projects than for the multi-owner projects identified by DNRC or SCS. The following paragraphs describe the procedures used in each case.

Operator Interest Projects

The field crew usually consisted of a soil scientist and an agricultural engineer. They were equipped with the necessary tools, field forms, and the landowner's project file. An appointment for the field inspection was arranged by telephone with each landowner. The investigation began with a review of the file with the landowner. The topics most often discussed were past water availability, cropping history, yields, and future development plans. Maps and photos were reviewed to verify ownership and project area boundaries. The landowner often accompanied the crew to the project area to observe the procedures.

A resource inventory field form (see Appendix E) was completed in the field for each project. This form required information about the type and location of each water source, its flow rate, suitability as a pumping site, and power availability . Notes recorded any physical constraints to water delivery such as topography, roadways, utility lines, or buildings. Existing irrigation systems were evaluated as sources of supplemental water. Notes described the water source, pump unit, and conveyance system.

The configuration of the land proposed to be irrigated was evaluated in order to suggest a suitable type of irrigation system. Land clearing or leveling requirements were recorded. A hand level and measuring rod were used to determine the elevation difference between the proposed water source and the land. For future reference color print photographs were taken of the proposed land and point of diversion.

A storage site information form (see Appendix E) was completed for proposed projects with water storage. The embankment and spillway were located and delineated on a topographic map, and the dam's height and length were measured. Preliminary measurements of the reservoir pool area were made, and land use within the inundated area was noted. Potential downstream flood hazards and dam site geologic constraints including bedrock lithology, stability, and attitude were also observed and recorded.

The dominant soil types within each field were characterized by the soil scientist. A standardized field form (see Appendix E) was used to document soil conditions and record any limitations for specific irrigation systems. Surface soil and subsoil characteristics were described from 3-inch bucket auger borings to a depth of 5 feet or until an impenetrable layer was hit. Particle size distribution was estimated by hand texturing. Coarse fragment content was estimated, and soil structure was described. Texture and structure characteristics were combined to estimate soil permeability. Dilute hydrochloric acid was used to test for the presence of carbonates.

The proposed irrigated land was traversed to note evidence of poor drainage, salinity or alkalinity problems, or accelerated erosion. Stream-cut banks, road cuts, and other soil exposures provided additional information about soil depth, drainage, and lateral variability. Irrigation feasibility also was assessed by noting any irrigation systems operating on adjacent or nearby lands.

In addition to the engineering and soils screening, each project was surveyed for environmental resources of special concern. An Environmental Field Checklist (see Appendix E) was used to record the occurrence of certain cultural and biological resources. Cultural resources included evidence of prehistoric or historic human activity and designated recreation facilities. Biological resources of concern included riparian communities, wetlands, and nesting or feeding sites for waterfowl and raptors. Any wildlife observed during the field investigation were noted on the environmental checklist.

DNRC- and SCS-Identified Projects

Proposed irrigation projects identified by DNRC or SCS received a more cursory field examination than the operator-identified projects. Since landowner permission to traverse the areas had not been obtained, the areas were examined from adjacent roadways or from aircraft. These inspections identified current irrigation, topographic constraints to system design, land clearing and leveling requirements, and obstacles such as roadways, utility lines, and buildings. An environmental checklist (see Appendix E) was completed, and color print photographs of each project were taken and placed in project files for future reference.

IRRIGATION DESIGN, AND ECONOMIC AND FINANCIAL EVALUATION

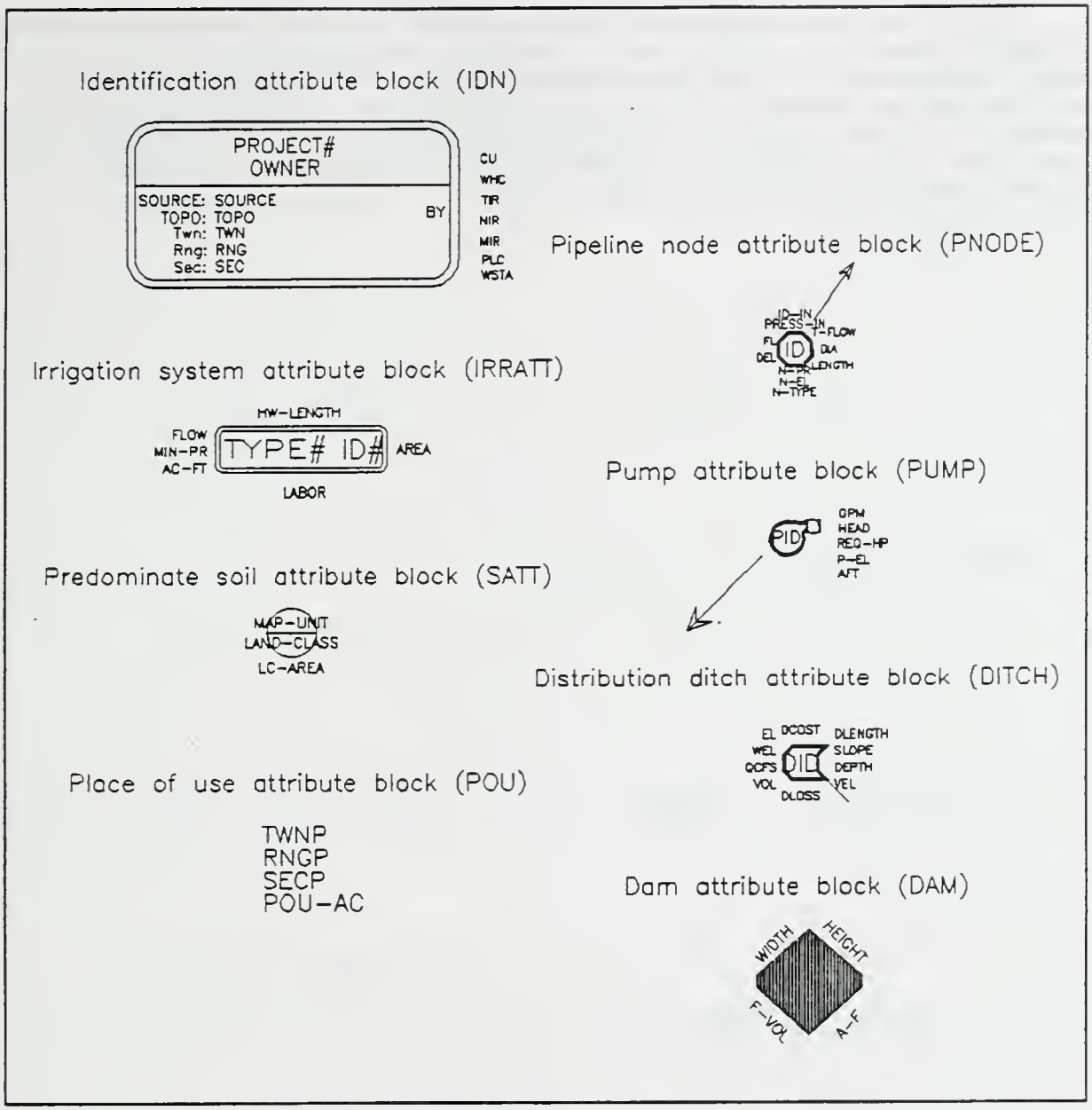
To ensure that irrigation projects included in the conservation district application were feasible, DNRC developed a reconnaissance-level irrigation system design and evaluation method. The method incorporates computer aided design (AutoCAD 9.0) and computer spreadsheet (Lotus 123 2.01) software along with a graphics-capable computer work station to quickly and accurately design, draft, and evaluate irrigation systems.

Irrigation Systems Design

Irrigation system designs were developed on identified irrigable lands using AutoCAD. AutoCAD is an open architecture graphics software program that allows the user to modify the program for a specific purpose. With AutoCAD the user can draw points, lines, and geometric objects and perform freehand traces. These drawing components or "entities" are drafted onto the computer screen using an input device called a "digitizing tablet." The digitizing tablet can be calibrated to any map scale. Using a digitizing tablet and a printer or plotter, these entities can be drafted and reproduced on a map at any desired scale.

AutoCAD also allows the user to enter information or "attributes" associated with each drawing entity. Together, the entities and their attributes are referred to as "blocks." The information in each block can be written to an intermediate file for use in Lotus 123 spreadsheets. Finally, AutoCAD allows the user to write interactive "LISP" programs. These programs can draw and manipulate entities and query the user for information used in entities and attributed blocks. Eight attributed blocks are used in the irrigation design process (Figure 2).

Figure 2. Attributed blocks used in the irrigation design process.



To design an irrigation system, a base map of the identified area is calibrated to the tablet and the design information entered. The designer uses AutoCAD LISP programs that perform calculations necessary for the designs and insert standard symbols for system features at the designer's discretion.

When the design is finished, the attribute information is transferred to a spreadsheet that performs the economic analysis and formats the information to be used in the application. This process is more thoroughly explained and documented in "Computer Aided Evaluation of the Value of Water for Irrigation" (Greiman 1990).

Figures 3 and 4 show a legend defining the entities used in the irrigation design process and an example of an irrigation system design. When the design is completed, the information is sent to the irrigation design analysis (IDA) spreadsheet (see example in Table 2). This spreadsheet calculates the total system costs and amortizes these costs over the repayment period to determine the annual costs. This annual cost includes energy and labor costs along with operation and maintenance costs. The total annual irrigation costs per acre are then compared to the percentile feasibility table to determine the project's feasibility rating (see Economic Evaluation section).

Figure 3. Legend for AutoCAD irrigation design

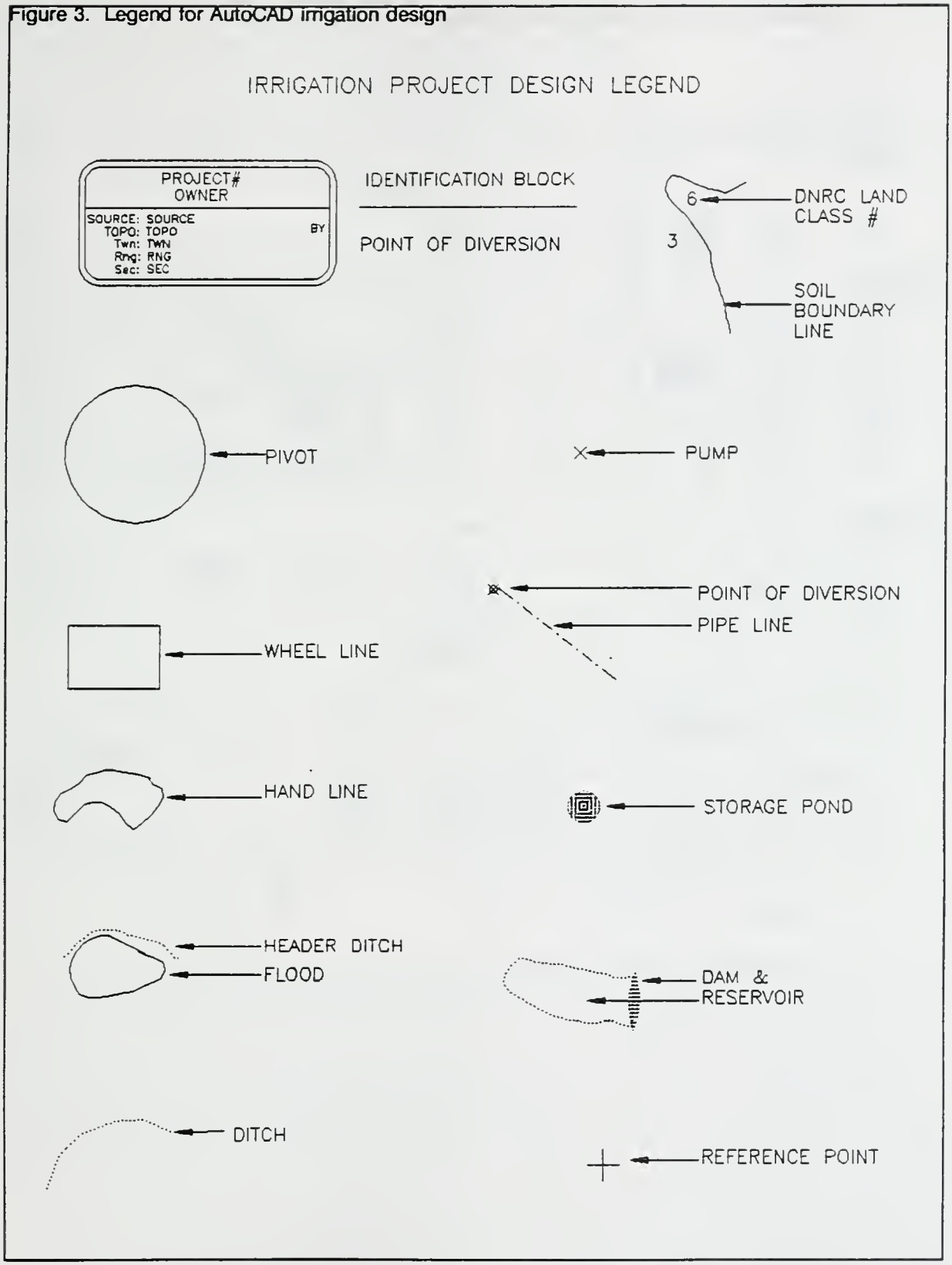


Figure 4. An example of an AutoCAD irrigation design

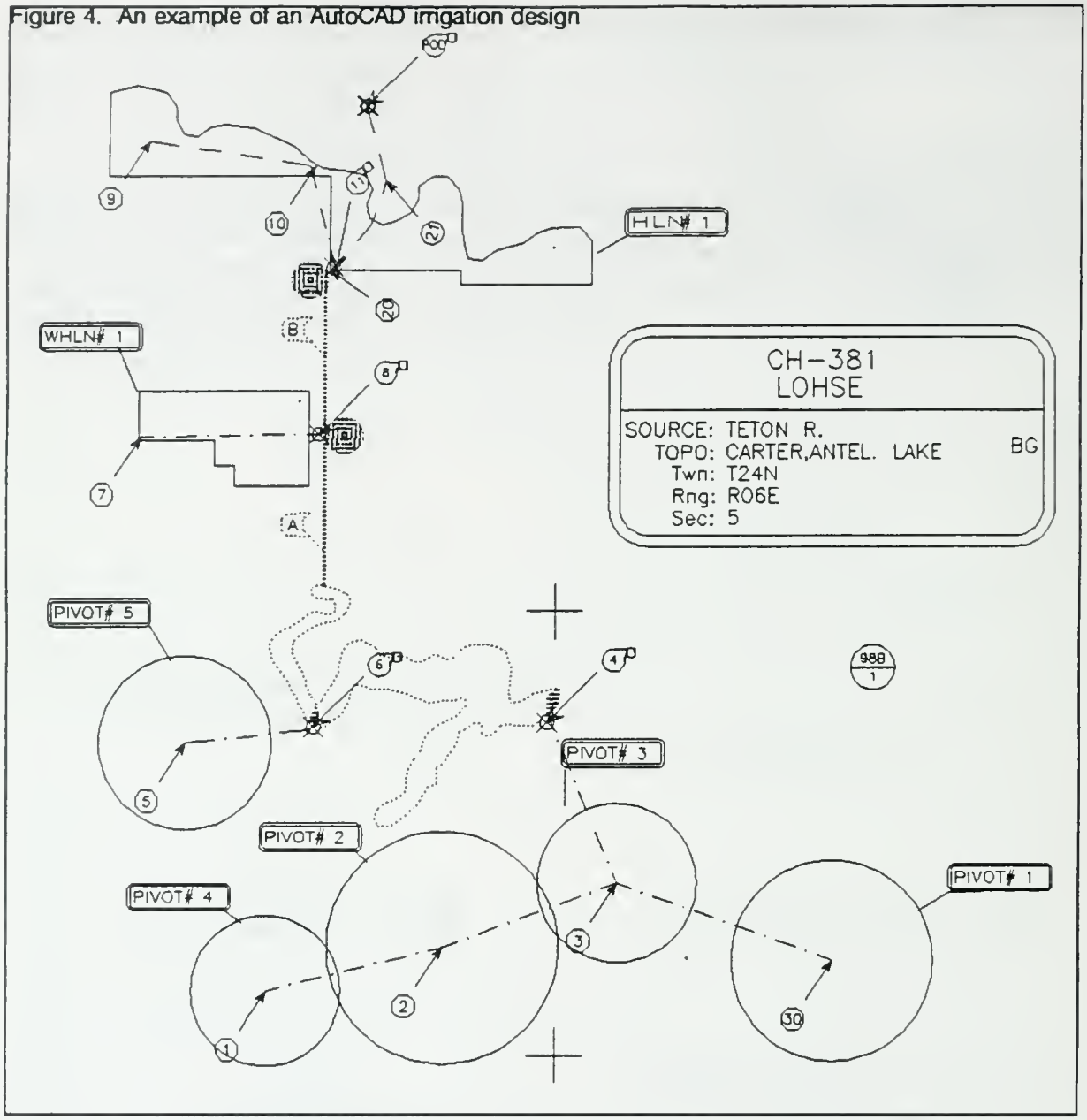


Table 2. Example of Irrigation Costs Table from IDA Spreadsheet

IRRIGATION COSTS TABLE

ITEM	COST/ UNIT	# OF ITEMS	UNITS	T. COST $1	% O&M	O&M	LIFE	ECON ANN-COST TOTAL	FINAN. ANN-COST TOTAL	COST/AC
Flood				$0	10.0%	$0	20	$0	$0	$0
Line				$16,680	1.5%	$250	10	$2,369	$2,965	$29
Pivot				$138,819	3.0%	$4,165	20	$14,929	$26,757	$238
Other				$0	1.5%	$0	10	$0	$0	$0
Other			unit	$0	5.0%	$0	10	$0	$0	$0
ON-FARM TOTALS				$155,499		$4,415		$17,298	$29,722	$266
Pump		710	hp	$87,096	2.5%	$2,177	30	$7,587	$16,352	$149
Engine		0	hp	$0	5.5%	$0	16	$0	$0	$0
Diversion	$2,000	9.9	cfs	$19,702	1.0%	$197	30	$1,421	$3,403	$34
Pump controls		10%p.	cost	$8,710	1.0%	$87	20	$762	$1,505	$15
Pipe	$154,375	110%		$169,813	0.5%	$849	50	$9,582	$28,485	$291
Ditches	$88,023	110%		$96,825	5.0%	$4,841	20	$12,349	$20,599	$166
Storage	$0	513	ac-ft	$124,390	1.0%	$1,244	50	$7,641	$21,488	$213
Other			unit	$0	2.0%	$0	50	$0	$0	$0
SYSTEM TOTALS				$506,536		$9,396		$39,343	$91,832	$867
Power dev.	$12,500	5.0	miles	$0			50	$0	$0	$0
Engineering		15%S.	total	$75,980			50	$3,907	$12,365	$130
Contingency		10%S.	total	$50,654			50	$2,605	$8,244	$87
TOTAL				$788,669		$13,811		$63,154	$142,163	$1,350

TOTAL ANNUAL COSTS	ECONOMIC TOTAL	/AC	/AC-FT	FINANCIAL TOTAL	/AC	/AC-FT
LABOR	$4,050	$6.93	$2.89			
ENERGY	$25,466	$43.58	$18.16			
EQUIPMENT	$63,154	$108.08	$45.05	$142,163	$243.30	$101.40
TOTAL annual costs	$92,670	$158.60	$66.10	$171,679	$293.82	$122.45

Economic Evaluation

Water reservation applications must contain an analysis of the direct benefits and costs associated with applying reserved water to the proposed beneficial use (MCA 85-2-316(C)(a)). This section presents the economic analysis used to fulfill these requirements and to determine whether a proposed irrigation project is economically feasible. Financial analyses also were developed to determine the likelihood of a project's being built. The methods presented were used to evaluate all irrigation projects included in conservation district applications.

Numerous factors affect the economic feasibility of irrigation development, but the choice of crop defines the overall potential for development. In almost all cases, it was assumed that alfalfa would be the primary crop grown. Area-specific precipitation and frost-free days information was used to estimate total consumptive use and peak alfalfa yield. Several studies (Bauer, et al 1974, Hill 1981, USDI 1983, Wilcox 1978, and Wright 1981) have analyzed yields versus total consumptive use. While each study had slightly different results, a general relationship between total consumptive use and potential alfalfa yield was established. This relationship was used to identify the peak yield per acre. Consumptive use estimates were based on the SCS MT_TR21 model (USDA 1988a) using data from 17 weather stations in the Missouri basin.

An eight-year rotation, where alfalfa is grown for the first seven years followed by one year of small grain production, was assumed. Alfalfa yields were estimated by proportioning the yields reported in "Optimal Replacement of Alfalfa Stands: A Farm Level Decision Model" (Stauber and Goodman 1986) with estimated peak alfalfa yields for specific climatic conditions. At the end of the seventh year, the stand of alfalfa is assumed to be replaced with a small grain crop. The following year, alfalfa is planted, and the cycle begins again. A 70-year planning period was used.

The next step was to develop a price forecast that, when combined with yield information, would provide an estimate of gross revenue per acre. A statistical relationship was established between alfalfa prices and a number of variables including lagged alfalfa prices, calf prices, wheat prices, state-wide alfalfa production, and precipitation. Forecast prices were based on this statistical relationship and on a random element. Because the forecast prices were influenced by random events, 300 forecasts were made for the 70-year planning period.

Forecasts of grain prices also were made because the stand is replaced by a grain crop in one out of eight years. Grain yields are more constant than alfalfa, so an average yield of 70 bushels per acre was assumed. The results were found to be insensitive to grain yields. For years when alfalfa has been plowed under and grain planted, the gross revenue was calculated by multiplying the grain yield by the forecast price of grain in that year.

Production costs also vary with yield. The production costs at varying yields for establishing alfalfa, established alfalfa, and irrigated grain were based on a crop enterprise budget, machinery costs, and a farm enterprise budget. When combined, these budgets account for all production costs except for the irrigation development costs.

Annual net revenues were calculated by subtracting per acre production costs from gross revenues. This was calculated for each year in the planning period and for each of the 300 forecast scenarios. The estimated annual net revenue was discounted to the present using a 4.6 percent real discount rate. Discounting weights the net revenues in the early part of the planning period more heavily than those in the later part of the planning period.

The discounted annual net revenues are summed to arrive at a net present value for the entire 70-year planning period. Because irrigation system costs were calculated on an annual basis, these

present net values were amortized for comparison. The result is that irrigation projects were categorized by the number of scenarios in which amortized net revenues exceed annual irrigation costs. For example, if the lowest amortized net revenue was $75 per acre per year and the irrigation system cost was $70 per acre per year, then the irrigation project is feasible in all 300 scenarios and has a percentile level of 100 percent. For each irrigation project analyzed, a percentile feasibility level has been determined. This percentile feasibility level represents the percentage of scenarios where irrigation system costs were less than amortized net revenues.

Choice of Crop and Farm Operation

The feasibility of a project depends highly on the type of crop grown. For this analysis, it was assumed that alfalfa would be grown, with a rotation of small grains. Early in the development of the methodology it was clear that using one crop to evaluate all projects would provide consistency between projects and conservation districts. When the department surveyed agricultural operators in the mid-Missouri basin of Montana, 65 percent of the respondents planned to grow either hay or alfalfa. The remaining 35 percent indicated they would grow small grain. This suggested that the crop should be either alfalfa or small grains. DNRC analyzed the economic feasibility of growing alfalfa rather than other crops. A study DNRC funded to assess the feasibility of high lift irrigation in the Yellowstone River valley showed that it was more profitable to grow and harvest alfalfa than other crops (Greiman 1986). For small grain production, it is important to keep in mind that the analysis excluded government subsidies that would add to the feasibility of growing these crops.

Production costs also vary with individual farm situations and the farm's annual yield. Individual farms have varying production costs, mainly because the efficiency in their use of their machinery varies. Generally, larger farms have lower production costs, up to a point, because they can get more use out of their machinery. Therefore, it is important to determine farm size and farming practices in order to determine cost of production. This, however, would be difficult and impractical to do for every farm involved in the water reservation program. DNRC has reviewed agricultural statistics for the 18 counties in the project area and found that the average amount of irrigated land for an irrigated farm is approximately 240 acres. However, very few farms have only irrigated farmland. Most also have dryland crops and range. Therefore, DNRC used a representative farm that has 460 acres of dryland, 240 acres of irrigated cropland, and enough rangeland to support 160 head of beef cattle. The farm would be raising alfalfa to winter its beef cattle. This "typical" small farm in the area was used to establish all production costs.

Peak Yield Estimate

Alfalfa yield is assumed to be directly related to the crop's water consumption. Several regional studies (Bauer et al 1974, Hill 1981, USDI 1983, Wilcox 1978, and Wright 1981) have analyzed yields in relation to consumptive use of water. While each study had slightly different results, a generally positive relationship between the consumptive use of water and potential alfalfa yield is obtainable. Figure 5 shows the results of a linear regression of the data collected from four regional research programs on alfalfa yield verses total crop consumption of water (evapotranspiration or ET). All yield data are adjusted to tons per acre at 12 percent moisture. The average relationship is the linear regression of all data of the four studies.

Figure 5. Linear relationship of yield in relation to ET for alfalfa

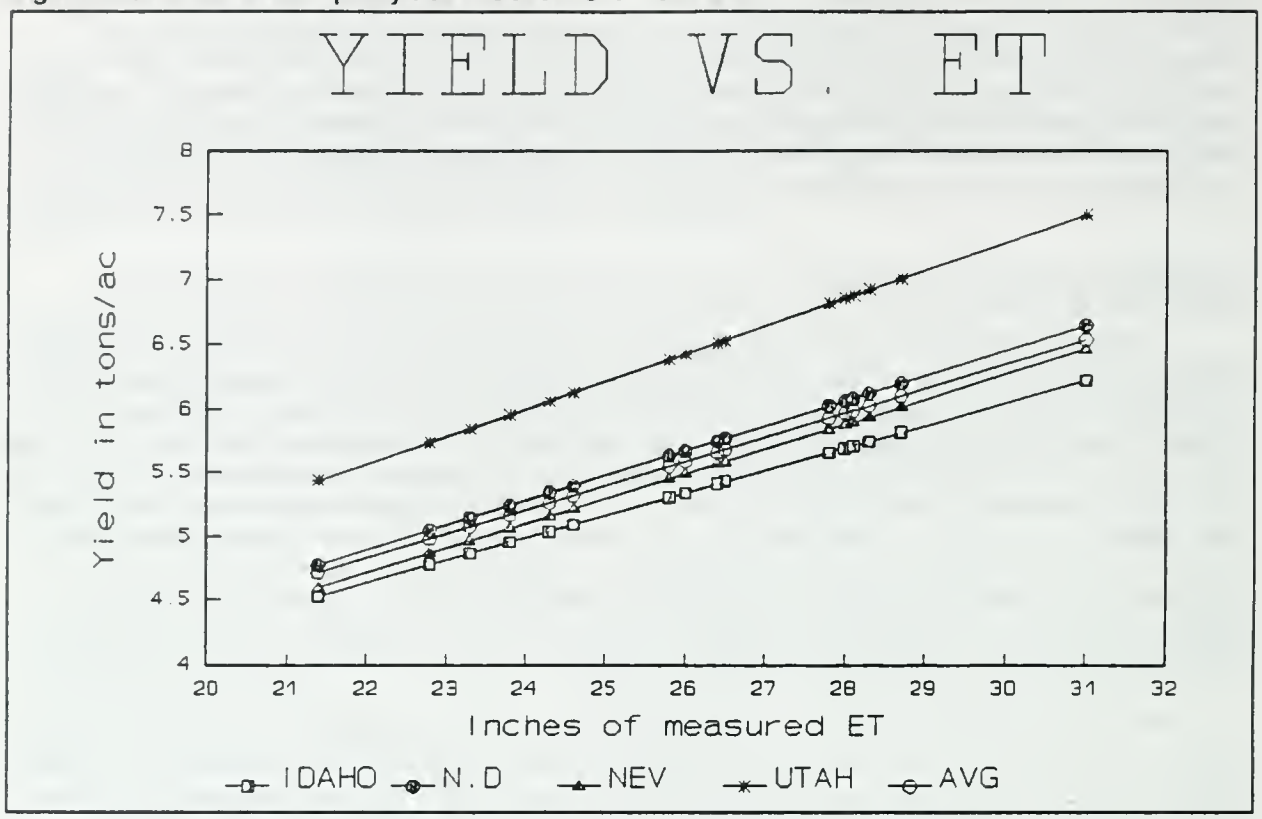


Table 3 shows the linear coefficients to determine peak attainable yield from total evapotranspiration for the four study sites and the average of those four sites. Table 4 shows the peak attainable yield predicted by the equation for the 17 weather stations used in the Missouri basin water reservation proceedings.

Table 3. Regression Equation and Linear Coefficients Used to Determine Peak Attainable Yield from Total Evapotranspiration

Yield = C + A * (ET)	KIMBERLY IDAHO	OAKES N.D.	FALLON NEV.	FLOWELL UTAH	AVG.
C coefficient	0.75	0.58	0.41	0.83	0.63
A coefficient	0.18	0.20	0.20	0.22	0.19

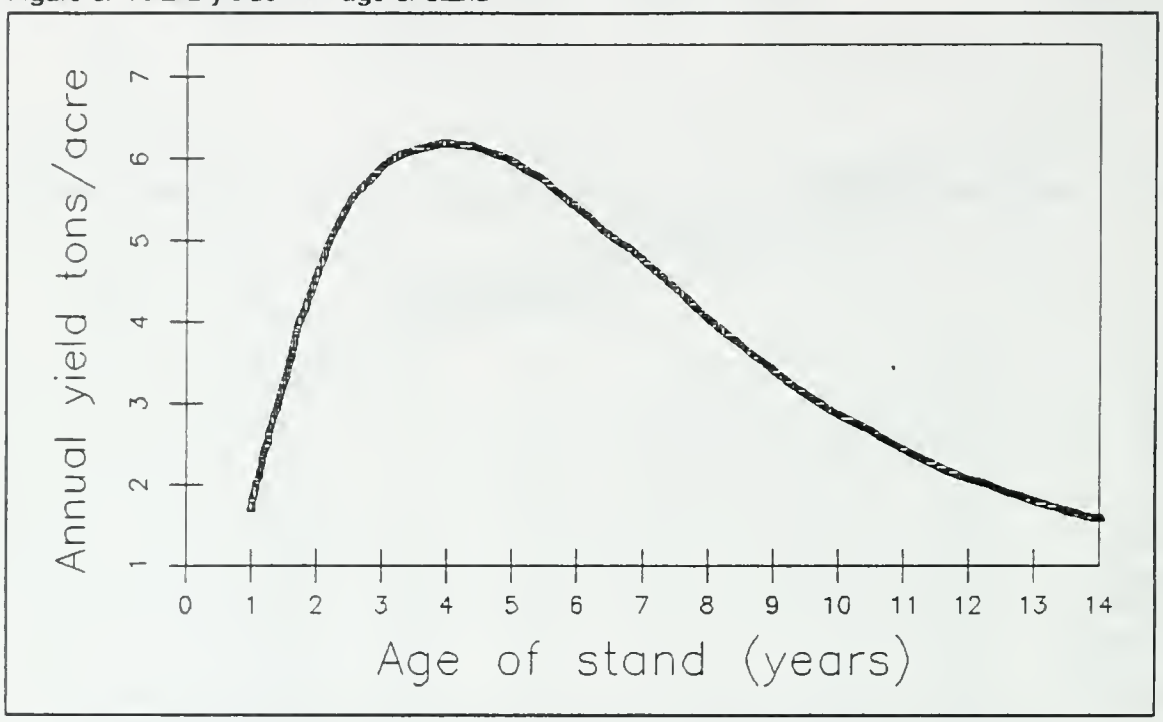
Table 4. Peak Attainable Alfalfa Yield for 17 Stations in the Missouri Basin

SITE	ET	YIELD (TONS/ACRE)				
Augusta	22.80	4.8	5.0	4.9	5.7	5.0
Cascade	25.80	5.3	5.6	5.4	6.4	5.5
Chester	23.80	4.9	5.2	5.1	5.9	5.2
Choteau	24.60	5.1	5.4	5.2	6.1	5.3
Conrad	24.30	5.0	5.3	5.1	6.1	5.3
Cut Bank	21.40	4.5	4.8	4.6	5.4	4.7
Fairfield	26.00	5.3	5.7	5.5	6.4	5.6
Ft. Benton	28.00	5.7	6.1	5.9	6.9	6.0
Geraldine	23.30	4.9	5.1	5.0	5.8	5.1
Grassrange	26.50	5.4	5.8	5.6	6.5	5.7
Great Falls	28.10	5.7	6.1	5.9	6.9	6.0
Culbertson	26.40	5.4	5.7	5.6	6.5	5.7
Havre	27.80	5.6	6.0	5.8	6.8	5.9
Malta	28.30	5.7	6.1	5.9	6.9	6.0
Poplar	28.70	5.8	6.2	6.0	7.0	6.1
Wolf Point	28.10	5.7	6.1	5.9	6.9	6.0
Glasgow	27.50	5.6	6.0	5.8	6.7	5.9

Annual Production

Alfalfa yields vary over the life of the stand and are a function of climatic conditions. Typically, alfalfa yields increase for the first four years and then begin a gradual decline (see Figure 6). Yield was estimated for each year.

Figure 6. Alfalfa yields with age of stand



Source: Stauber and Goodman 1986

Stauber and Goodman's 1986 article, "Optimal Replacement of Alfalfa Stands: A Farm Level Decision Model," analyzed alfalfa production based on alfalfa stand age. This article presented the best production information that was available on stand age and yield. Using this information, DNRC estimated annual production for all of the projects that were reviewed. The peak yields described above reflect the climactic conditions at the various weather stations in the Missouri basin. The ratio of this peak yield divided by the 5.2 tons per acre peak yield presented in Stauber and Goodman's 1986 article was used to adjust the annual production figures that were also presented in the 1986 article. Table 5 shows the farm-attainable yields for the rotation period for all weather stations used in the Missouri basin water reservation proceedings. Research indicates that peak attainable yield from experiment stations overestimates the practical attainable yield of a farm by 10 percent to 20 percent. Therefore, the peak attainable yields have been reduced by a .9 multiplier to determine farm-attainable yields for the weather stations shown in Table 5.

Table 5. Farm-Attainable Alfalfa Yield for Selected Weather Stations

WEATHER STATION	YIELDS BY YEAR AFTER PLANTING							AVG.	ADJUSTED AVERAGE
	1	2	3	4	5	6	7		
Augusta	1.2	3.4	4.1	4.5	4.3	4.0	3.4	3.6	3.9
Cascade	1.3	3.7	4.6	5.0	4.8	4.4	3.8	4.0	4.4
Chester	1.3	3.5	4.3	4.6	4.5	4.1	3.6	3.7	4.1
Choteau	1.3	3.6	4.4	4.8	4.6	4.2	3.7	3.8	4.2
Conrad	1.3	3.5	4.4	4.7	4.5	4.2	3.6	3.8	4.2
Cut Bank	1.1	3.2	3.9	4.2	4.1	3.7	3.3	3.4	3.7
Fairfield	1.4	3.8	4.6	5.0	4.8	4.4	3.9	4.0	4.4
Ft. Benton	1.4	4.0	5.0	5.4	5.2	4.7	4.1	4.3	4.7
Geraldine	1.2	3.4	4.2	4.6	4.4	4.0	3.5	3.6	4.0
Grassrange	1.4	3.8	4.7	5.1	4.9	4.5	3.9	4.1	4.5
Great Falls	1.4	4.0	5.0	5.4	5.2	4.8	4.1	4.3	4.7
Culbertson	1.4	3.8	4.7	5.1	4.9	4.5	3.9	4.0	4.5
Havre	1.4	4.0	4.9	5.3	5.1	4.7	4.1	4.2	4.7
Malta	1.5	4.1	5.0	5.4	5.2	4.8	4.2	4.3	4.8
Poplar	1.5	4.1	5.1	5.5	5.3	4.9	4.2	4.4	4.8
Wolf Point	1.6	4.4	5.4	5.9	5.7	5.2	4.5	4.7	5.2
Glasgow	1.4	4.0	4.9	5.3	5.1	4.7	4.1	4.2	4.7

The Stauber and Goodman article also discussed the importance of stand age and expected price on the decision to replace a stand of alfalfa. Their analysis showed that discounted net annual crop revenues were maximized if the stand was replaced every 8 years. DNRC confirmed this result by running the model described in this paper for a range of rotation lengths from 6 to 10 years for 120 different price forecasts. As shown in Table 6 an 8-year rotation produced the highest net present value (NPV) for more price forecasts than any other rotation length. Therefore, an 8-year rotation was assumed.

Table 6. Distribution of Rotation Length Producing the Highest Net Present Value (NPV) for 120 Forecasts

Rotation length (years)	6	7	8	9	10
Number of occurrences of highest NPV	3	35	39	12	1

It was assumed that, when the alfalfa is plowed, it is replaced with a small grain crop for one year and then replanted. This rotation is done to reduce weeds and other problems that can occur if alfalfa is immediately replanted. Because small grain yields are more constant, an irrigated yield of 70 bushels per acre was assumed for all projects. When the model was originally developed, grain yields varying from 60 to 80 bushels per acre were tested. The results of the model were found to be insensitive to these variations.

Cost of Production

DNRC adopted the method established in "Computer-Aided Evaluation of the Value of Water for Irrigation" (Greiman 1990) to determine the cost of production for alfalfa and grain at various yields. This method uses an interactive computer-aided irrigation design (CAID) program and three different computer spreadsheets to budget all the costs associated with irrigation development. The normal process is to design the irrigation system and find the annual ownership and operating costs using the CAID program and irrigation design analysis (IDA) spreadsheet. This information is then entered, along with the machinery ownership cost obtained from the machinery use (MU) spreadsheet, into the enterprise analysis (EA) spreadsheet to determine the total production costs and revenue generated by the farm.

However, this process had to be modified to supply information for the price forecasting-percentile feasibility model. This model requires production cost per ton for establishing and established alfalfa over a range of yields. This was accomplished by eliminating all machinery costs and irrigation costs from the EA spreadsheet. Therefore, this spreadsheet is used to determine the non-yield dependent cost of production for each crop. This production cost is then added to the annual machinery costs for each crop in the MU spreadsheet. Using the MU spreadsheet, the total production cost, less irrigation costs, can be found for a crop at a desired yield. The EA spreadsheet is then recalculated with incremental increases in yields to determine the associated farm costs. This was done in one-tenth of a ton per acre increments for alfalfa. Table 7 shows the production cost (irrigation costs not included) for establishing irrigated alfalfa, established irrigated alfalfa, and irrigated grain.

Table 7. Crop Production Costs at Various Yields.
(Excluding Irrigation Costs)

Irrigated Grain Yield (Bushel)	Cost/Bushel	First Year Alfalfa Yield	(Cost/Ton)	Established Alfalfa Yield	(Cost/Ton)
70	$1.83	0.1	$1,175.60	3.0	$27.67
		0.2	$594.13	3.1	$27.17
		0.3	$400.29	3.2	$26.70
		0.4	$303.37	3.3	$26.26
		0.5	$245.22	3.4	$25.84
		0.6	$206.45	3.5	$25.44
		0.7	$178.75	3.6	$25.07
		0.8	$157.98	3.7	$24.71
		0.9	$141.82	3.8	$24.37
		1.0	$128.90	3.9	$24.04
		1.1	$118.32	4.0	$23.74
		1.2	$109.51	4.1	$23.44
		1.3	$102.05	4.2	$23.16
		1.4	$95.65	4.3	$22.90
		1.5	$90.11	4.4	$22.64
		1.6	$85.26	4.5	$22.40
		1.7	$80.98	4.6	$22.17
		1.8	$77.17	4.7	$21.94
		1.9	$73.77	4.8	$21.73
		2.0	$70.70	4.9	$21.52
		2.1	$67.93	5.0	$21.32
		2.2	$65.41	5.1	$21.13
		2.3	$63.11	5.2	$20.94
		2.4	$61.00	5.3	$20.77
		2.5	$59.05	5.4	$20.59
		2.6	$57.26	5.5	$20.43
		2.7	$55.60	5.6	$20.27
		2.8	$54.06	5.7	$20.11
		2.9	$52.62	5.8	$19.96
		3.0	$51.28	5.9	$19.82
				6.0	$19.68

Tables 8 and 9 show the input variables for the MU and EA spreadsheets.

Table 8. Machinery Use Spreadsheet Input Sheet and Summary.

ECONOMIC VARIABLES

Current year		88	prices based on 1984 list price
Interest rate (.01 = 10.00%)	INR	4.60%	
Inflation rate (ave)	IFR	3.20%	
Real rate of return	RRR	4.60%	
Inflation factor since 1984	IFF	1.13	
Discount from list price	DIS	0.80	
1984 list price multiplier	LPM	0.91	
Taxes and ins. as % of ave. value	T&I	1.5%	
Percentage of ASAE repair cost used	%RC	75%	
Fuel price (diesel)	DFP	$1.00 /gal	
Maximum years of ownership	MAX	20 yrs	
Labor costs	LBC	$5.00 /hr	
Return on investment	RET	5%	

CROP VARIABLES

	ACRES	EST. YIELD	LBS/UNIT	TRUCK-HR /LOAD	TON STRAW YIELD	# OF TR USED 1,2,or3	AX-HR/AC
ALF. EST	30 ac	1.0 ton/ac	2000	1		1	0.10 ALF. EST
ALF	180 ac	6.0 ton/ac	2000	1		1	0.60 ALF
IRR G	30 ac	70.0 bu/ac	60	2.5		2	0.53 IRR G
DL G	230 ac cpd	45 bu/ac	60	2.5		2	0.34 DL G
C-C	160 hd	0.9 calf/hd	1500	6	1	2	0.51 C-C
	630 ac						

COST SUMMARY OF MACHINERY

	RAISED	FIXED	VARIABLE	TOTAL	LABOR	PROD. COST	COST/ UNIT	COST/ UNIT
ALF. EST	30 ac	$18.53	$22.66	$41.19	$7.19	$79.15	0.6	$128.13
ALF	180 ac	$23.07	$35.06	$58.13	$13.96	$42.40	0.6	$19.68
IRR G	30 ac	$39.92	$31.63	$71.55	$5.42	$50.21	0.5	$1.82
DL G	230 ac	$28.32	$28.60	$56.92	$6.26	$22.61	0.25	$2.16
C-C	160 ac	$9.30	$12.55	$21.85	$5.58	$256.00		

Table 9. System Variables for the Enterprise Analysis Spreadsheet.

SYSTEM VARIABLES			PERCENT LAND DEBT	
Irr. land value	ILV	$650 /ac	ILD	16%
Dryland value	DLV	$200 /ac	DLD	16%
Grassland value	GLV	$75 /ac	GLD	16%
Interest rate	INR	4.60%		
Terms	TRM	40 year	AMF	0.06 I27: @PMT(1,INR,TRM)
Interest on operating capital	OCI	10.00%		
Return to farm (opportunity costs)	RET	5.00%		
Percent of dryland cropped	PDC	50% cropped/yr		
Rangeland capacity	RLC	0.50 ann aum/ac		$150 I31: GLV/RLC
Amount of grassland owned	GLO	3,000 acres		
Vehicle miles charged to farm/yr	VMI	10,000 /yr a		$0.20 $/mile
Return to management	RTM	$0 /yr		
Other fixed costs	OTH	$1,000 /yr		housing
Misc. costs	MIS	5%		
Land taxes (% of land value)	LTX	0.30%		
Insurance (% of crop value)	CIN	1.0%		
Labor costs	LCT	$5.00 /hr		
Irrigation labor hrs/ac	ILA	0.0 hr/ac		

Price Forecast

Alfalfa price forecasts are based on the statistical relationship between past alfalfa prices and important independent variables that influence this price. The data used to estimate the equations were collected by the Montana Crop and Livestock Reporting Service. Monthly price data from 1948 through 1985 for alfalfa, spring wheat, barley, and calves were used. Additional data on annual hay production and precipitation also were included.

Initially, all variables were lagged 24 periods, or two years. This provided a total of 144 variables that were analyzed for their impact on alfalfa prices. Due to the large number of observations and potential independent variables, and the possible complexity of the lag structure, all candidate independent variables could not be regressed on alfalfa price simultaneously using the hardware and software available. To get around this problem, the data were divided into seven blocks of regressors. Six regressions were run with the regressors in each run consisting of the variables in block one and one of the other blocks. Variables in block one that were never significant and whose exclusion did not have a significant effect on other coefficients were dropped, and the remaining variables in block one were combined with another block.

This became a new block one, and regressions were run combining the new block one with each of the other blocks. Variables in block one that were never significant and whose exclusion did not have a significant effect on other coefficients were dropped, and the process was continued until only one block remained. At this point, the equation contained a constant term, a time trend, selected month dummies, lagged alfalfa prices, current and/or lagged precipitation, quantity of hay, barley, wheat, oats, and calves.

This model was still considered too large, and further variables were dropped. The criteria for dropping a variable were that it had a small t statistic, that dropping the variable reduced the standard error of the estimate, and that dropping the variable did not significantly affect the values of other coefficients. The model specification after this process is shown in Table 10.

Table 10. Alfalfa Price Equation (Ordinary Least Squares Results).

Observations:	444	Degrees of freedom:	421
R-squared :	0.958	Rbar-squared :	0.956
Residual SS :	8142.600	Std error of est :	4.398
Total SS :	1.931E+005	F(23 ,421)=434.6309	P-value=0.00

Var	Coef	Std. Error	t-Stat	P-value
Constant	8.832698	3.28194	2.6913	0.007
Time	-0.008721	0.00603	-1.4456	0.148
March	-2.293984	0.82672	-2.7748	0.006
April	-2.121646	0.83205	-2.5499	0.011
May	-1.24497	0.82862	-1.5025	0.133
June	-2.841	0.81436	-3.4886	0
July	-3.484654	0.83814	-4.1576	0
P alfalfa-1	1.10529	0.04715	23.4425	0
P alfalfa-2	-0.245328	0.04865	-5.0431	0
P alfalfa-6	-0.077835	0.04978	-1.5635	0.118
P alfalfa-7	0.200504	0.07061	2.8398	0.005
P alfalfa-8	-0.125376	0.04783	-2.6214	0.009
Precip-5	-0.620161	0.30906	-2.0066	0.045
Q hay	-0.003045	0.00071	-4.2647	0
Q hay-12	0.002485	0.00089	2.80158	0.005
P barley	2.69676	0.55181	4.88715	0
P wheat-3	-0.609304	0.21272	-2.8643	0.004
P oats-8	1.023957	0.87077	1.17592	0.024
P calves-4	0.158357	0.14813	1.06904	0.285
P calves-5	0.360316	0.21474	1.67789	0.093
P calves-6	-0.42763	0.18433	-2.3199	0.02
P calves-8	0.278988	0.14473	1.92762	0.054
P calves-10	0.255611	0.10079	2.536	0.011

An autoregression of the residuals from this equation was run to detect autocorrelation. Possible autocorrelations of first, eleventh, and eighteenth orders were found. The joint hypothesis of autocorrelation of these orders could not be rejected at the 80 percent confidence level but was not accepted at the 90 percent level. The data were transformed to remove the suspected autocorrelations, and the model was re-estimated. The transformed model had a higher standard error of the estimate, and none of the coefficients changed significantly. The model based on untransformed data was therefore preferred.

When all of the estimated equations were combined, the forecasting model was still too large for the available hardware/software combination. Two steps were taken to further reduce its size. First, the hypothesis was tested and accepted that the remaining monthly dummies all had the same value. They were therefore replaced by a single dummy. An autoregressive error specification was also tested as an alternative to the large number of lagged dependent variables and lagged calf prices. Autoregressive processes of up to the eighth order were tested. The lowest standard error of the estimate was obtained with a second order autoregressive specification. This specification gave a smaller standard error of the

estimate than the model without the autoregressive error term and allowed all but one lag on both alfalfa price and calf price to be dropped.

This gave an equation that fit the data well and has a relatively small number of parameters. This equation is presented in Table 11.

Table 11. Autoregressive Alfalfa Price Equation. (Maximum Likelihood Results)

Observations:	344	Standard Error of Estimate:	4.150
R-squared:	0.945	Var of White Noise Error (sigsq1):	15.244
-2*log(L)/T:	5.562	Variance of sigsq1:	1.351

COEFFICIENTS OF INDEPENDENT VARIABLES (Beta)

Var	Coef	Std. Error	T-Ratio	P-Value
Constant	9.198289	3.639731	2.527189	0.011
Time	-0.011506	0.010732	-1.072118	0.284
Spring dum	-2.344880	0.551996	-4.248004	0.000
P alfalfa-1	0.848058	0.027496	30.843305	0.000
Precip-5	-0.619188	0.290477	-2.131625	0.033
Q hay	-0.003705	0.000887	-4.177841	0.000
Q hay -12	0.003078	0.001032	2.981644	0.003
P barley	2.824283	0.665591	4.243273	0.000
P wheat -3	-0.905490	0.313880	-2.884830	0.004
P oats -8	1.518555	1.523250	0.996918	0.319
P calves -4	0.189017	0.056537	3.343262	0.001

AUTOREGRESSIVE PARAMETERS (Phi)

Lag	Phi	Std. Error	T-Ratio	P-Value
1	0.356413	0.053769	6.628644	0.000
2	-0.073980	0.053769	-1.375895	0.169

The Precipitation Equation

Candidate regressors for precipitation were lagged values of precipitation, a time trend, and month dummies. Variables were dropped from this list if they had a small individual t statistic, dropping them reduced the standard error of the estimate, and dropping them did not significantly affect the values of other coefficients. The final model was tested for autocorrelation by performing an autoregression of the residuals, and no evidence of autocorrelation was found. The final precipitation equation is shown in Table 12.

Table 12. Precipitation Equation (Ordinary Least Squares Results).

Observations:	444	Degrees of freedom:	432
R-squared :	0.506	Rbar-squared :	0.494
Residual SS :	135.206	Std error of est :	0.559
Total SS :	273.795	F(12 ,432)=40.2557	P-value=0.00

Var	Coef	Std. Error	t-Stat	P-Value
CONSTANT	0.758387	0.097778	7.756175	0.000
Precip -2	0.094723	0.046852	2.021768	0.043
Precip -5	0.064252	0.043326	1.482991	0.138
Precip -12	-0.072293	0.048058	-1.504295	0.133
Feb dummy	-0.212312	0.103919	-2.043061	0.041
April dummy	0.452635	0.109006	4.152390	0.000
May dummy	1.474211	0.124670	11.824915	0.000
June dummy	1.792066	0.135754	13.200873	0.000
July dummy	0.447350	0.126077	3.548233	0.000
Aug dummy	0.372108	0.131016	2.840171	0.005
Sept dummy	0.418940	0.106139	3.947087	0.000
Nov dummy	-0.179922	0.113616	-1.583598	0.113

The procedure used to specify the equations for wheat price, barley price, and oats price was similar to that used for the alfalfa price equation. The only difference was that current and lagged alfalfa prices were excluded to produce a recursive structure for the overall model. The wheat price, barley price, and oats price equations are presented in Tables 13, 14, and 15.

Table 13. Wheat Price Equation (Maximum Likelihood Results).

Observations:	454	Standard Error of Estimate:	0.351
R-squared:	0.970	Var of White Noise Error (sigsql):	0.112
-2*log(L)/T:	0.646	Variance of sigsql:	5.495E-005

COEFFICIENTS OF INDEPENDENT VARIABLES (Beta)

Var	Coef	Std. Error	T-Ratio	P-Value
Constant	-0.049930	0.082035	-0.608639	0.543
P wheat -1	0.977346	0.012308	79.406786	0.000
P barley-1	0.168793	0.075590	2.233025	0.026
P barley-2	-0.158132	0.071458	-2.212953	0.027
P oats -2	-0.038924	0.035394	-1.099725	0.271
P calves-2	0.006338	0.002085	3.039072	0.002

AUTOREGRESSIVE PARAMETERS (Phi)

Lag	Phi	Std. Error	T-Ratio	P-Value
1	0.155428	0.046078	3.373146	0.001
2	-0.153690	0.046091	-3.334493	0.001
3	-0.189937	0.046078	-4.122079	0.000

Table 14. Barley Price Equation (Maximum Likelihood Results).

Observations:	454	Standard Error of Estimate:	0.206
R-squared:	0.957	Var of White Noise Error (sigsq1):	0.038
-2*log(L)/T:	-0.422	Variance of sigsq1:	0.000065

COEFFICIENTS OF INDEPENDENT VARIABLES (beta)

Var	Coef	Std. Error	T-Ratio	P-Value
Constant	-0.067358	0.063601	-1.059074	0.290
time	0.000101	0.000090	1.108724	0.268
P barley-1	0.950116	0.014436	65.813788	0.000
P wheat-1	0.057459	0.025177	2.282180	0.022
P wheat-2	-0.045264	0.025483	-1.776246	0.076
P calves-1	-0.016000	0.006353	-2.518484	0.012
P calves-2	0.020277	0.006283	3.227456	0.001

AUTOREGRESSIVE PARAMETERS (Phi)

Lag	Phi	Std. Error	T-Ratio	P-Value
1	0.175289	0.046826	3.743416	0.000
2	0.022686	0.047368	0.478936	0.632
3	-0.165741	0.047247	-3.507978	0.000
4	-0.075702	0.047247	-1.602255	0.109
5	-0.086798	0.047368	-1.832400	0.067
6	-0.067280	0.046826	-1.436818	0.151

Table 15. Oats Price Equation (Maximum Likelihood Results)

Dependent Variable:	P oats
Number of Observations:	454
R-squared:	0.980
Standard Error of Estimate:	0.071
Variance of White Noise Error (sigsq1):	0.004
Variance of sigsq1:	0.000000086
-2*log(likelihood)/T:	-2.581

COEFFICIENTS OF INDEPENDENT VARIABLES (Beta)

Var	Coef	Std. Error	T-Ratio	P-Value
Constant	-0.065591	0.012531	-5.234514	0.000
Time	0.000117	.000030	3.889882	0.000
P oats-1	0.982668	0.007089	138.613824	0.000
P wheat-1	0.004389	0.001698	2.585089	0.010
P barley-1	0.081486	0.013895	5.864241	0.000
P barley-2	-0.079767	0.013492	-5.912154	0.000
P calves-1	0.000905	0.000243	3.730067	0.000

AUTOREGRESSIVE PARAMETERS (Phi)

Lag	Phi	Std. Error	T-Ratio	P-Value
1	-0.264927	0.046878	-5.651372	0.000
2	-0.086839	0.047786	-1.817234	0.069
3	-0.083171	0.046826	-1.776186	0.076
4	-0.177016	0.046621	-3.796895	0.000
5	-0.124856	0.046621	-2.678097	0.007
6	-0.220919	0.046826	-4.717896	0.000
7	-0.176523	0.047786	-3.694013	0.000
8	-0.047954	0.046878	-1.022937	0.306

The Calf Price Equation

As with the alfalfa price equation, because of the large number of potential independent variables and the possible complexity of the lag structure, not all candidate independent variables could be regressed simultaneously on calf prices. Variables in the first block were excluded if they had a small t ratio and dropping them did not increase the standard error of the estimate. Additional variables were added. Again, variables with low t ratios were excluded if these did not increase the standard error of the estimate. This process continued until the final equation was identified.

The final equation was then tested for autocorrelation. Possible fifth order autocorrelation was found. The hypothesis of fifth order autocorrelation could not be rejected at the 80 percent confidence level but was not accepted at the 90 percent level. The data were transformed to remove the suspected autocorrelation, and the model was re-estimated. None of the coefficients changed significantly. The model based on the untransformed data was therefore preferred. The calf-price equation is presented in Table 16.

Table 16. Calf Price Equation (Ordinary Least Squares Results).

Column	Parameter Estimate	Standard Error	t-value (b=0)	Prob. (b=0)	Sequential R^2	Simple R^2
Constant	1.258889					
precip-8	0.261904	0.0864	3.03	0.003	0.0032	0.0032
precip-10	0.112393	0.0898	1.26	0.207	0.0079	0.0055
Pwheat-6	-0.187310	0.0790	-2.35	0.019	0.0108	0.0030
Pwheat-13	0.0992	0.0864	1.15	0.251	0.0811	0.0299
Pbarley-23	0.1011412	0.1010301	1.00	0.317	0.0835	0.0243
Poats-9	-0.4591016	0.1740137	-2.64	0.009	0.2648	0.1685
Pcalves-1	0.9720777	0.0335	41.41	0.000	0.9600	0.9563
Pcalves-13	-0.1381252	0.0241191	-5.73	0.000	0.9619	0.1777
Pcalves-20	2.81703E-02	0.0491188	0.57	0.567	0.9630	0.0062
Pcalves-21	0.0842	0.0524	1.61	0.109	0.9631	0.0024
Pcalves-24	-0.0503	0.0249	-2.02	0.044	0.9634	0.0014

	df	Sum off Squares (Sequential)	Mean Square	F-Ratio	Prob>
Constant	1	34,2304	34,2304		
Model	12	21,296.14	1,774.678	919.46	0.00
Error	419	808.7225	1.930125		
Total	431	22,104.86	51.28738		

Root Mean Square Error	1.38929
Mean of Dependent Variable	28.14907
Coefficient of Variation	0.0494
R Squared	0.9634
Adjusted R Squared	0.9624
Durbin-Watson Statistic	1.906089

The Hay Quantity Equation

Hay production is an annual figure and was estimated only as a function of its own past values and time. The specification that produced the lowest standard error of the estimate is shown in Table 17. An autoregression of the residuals was run to test for autocorrelation and no evidence of it was found.

Table 17. Hay Production Equation (Ordinary Least Squares Results)

Observations:	32	Degrees of Freedom:	27
R Squared:	0.691	Rbar Squared:	0.645
Residual SS:	3.810E+006	Std Error of Est.:	375.669
Total SS:	1.233E+007	F(5,27) = 15.0894	P-value = 0.00

Var	Coef	Std. Error	t-Stat	P-Value
Constant	2,283.883940	903.638847	2.527430	0.018
Q hay-1	0.482689	0.217181	2.222518	0.035
Q hay-4	-0.444125	0.266784	-1.664740	0.108
Time	118.438194	37.061602	3.195712	0.004
Time^2	-2.120967	0.892172	-2.377307	0.025

Discount Rate

The choice of a discount rate has been a debated issue over the last 20 years, especially with regard to water resource projects. DNRC's economist prepared a working paper concerning the choice of a discount rate to be used in the evaluation of energy conservation alternatives (Nordell 1984). This paper reviewed the rates used in previous DNRC analyses and also references an excellent book on the subject, Discounting for Time and Risk in Energy Policy (Lind, et al 1982). In this book, Lind argues that a real rate of 4.6 percent should be used. The 4.6 percent represents the average real rate of return, after taxes, on a market portfolio. Lind suggests that this rate be adjusted for risk and opportunity cost of capital. The price forecasting model deals with risk by identifying the percentage of times that the project is feasible. Therefore, this adjustment was not made. The majority of projects being considered are small and will most likely be built using private funds. Therefore, there is no need to adjust for the cost of capital in order to reflect public funding.

Planning Period and Number of Scenarios

A 70-year planning period was used in the analysis. This period was chosen because it captures 95 percent of the present value of an infinite stream of net returns without going past the probable life of the project or the period when the forecasts are likely to be useful. Because the model has a random component, 300 scenarios were forecasted. This number was chosen because the mean of net revenue for all of the forecasts converged at this point, and running additional scenarios did not capture any additional variation.

Net Revenue

The previous sections describe the variables that, when combined, form the net revenue calculation. The model was initialized by using the average of the last five years of price data. From

this the alfalfa price was forecast for the first year. This price was multiplied by yield to calculate gross revenue for the period. This yield was based on the climatic information for specific weather stations and stand age. The associated production cost was then subtracted to calculate net revenue. Annual net revenue was then discounted to reflect its value at the beginning of the forecast. Then the model forecast the price of alfalfa in the second year of production, based on the value of the independent variables in the price forecast in period 1. Net revenue was again calculated and discounted. This procedure was repeated until it reaches the 70th period. At that point, all of the discounted annual net revenues were summed to calculate a present value. The model repeated this process another 299 times. The difference between each forecast was a result of the random component of the model.

The net present value associated with each weather station and for 300 scenarios was then categorized by percentile. These values were then amortized to reflect constant annual revenues. This number was compared to the total annual cost of the proposed irrigation system (amortized capital costs plus operation and maintenance). In this way, each project that was reviewed was categorized by percentile feasibility level.

If a project's costs were lower than the amount available to pay for irrigation for all 300 scenarios, the project was classified as 100 percent feasible. Projects that fall within this category are insensitive to price variations and would be considered as an excellent project. If a project's costs exceeded the amount available to pay for new irrigation in 150 scenarios but were lower in the remaining 150 scenarios, the project was classified at the 50 percent feasibility level. This project would be much more risky to develop. Because DNRC was preparing water reservation applications on the behalf of conservation districts, projects with a feasibility as low as 10 percentile level were analyzed. Even though these projects are unlikely to pay for themselves, they were included in the applications so that the Board would consider the greatest number of projects.

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APPENDIX A: Methodology Review by Aquoneering

A METHODOLOGY REVIEW

WATER RESERVATION APPLICATIONS

MIDDLE MISSOURI RIVER

CONSERVATION DISTRICTS

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TABLE OF CONTENTS

SUMMARY ii

INTRODUCTION 1
PURPOSE 1

SCOPE OF WORK 2

STAFF CREDENTIALS 3
PROCEDURE 3
FINDINGS 4

METHODOLOGIES 7
PROJECT ORGANIZATION 7
WATER AVAILABILITY 10
SOILS INVESTIGATIONS 13
IRRIGATION DESIGN 15
FINANCIAL AND ECONOMIC FEASIBILITY 18

TYPICAL PROJECT REVIEW 20
FIELD INVESTIGATIONS 20
WATER AVAILABILITY 25
SOILS ANALYSIS 28
DESIGN AND COST ESTIMATES OF IRRIGATION SYSTEMS 33
GENERAL COMMENTS 40
FINANCIAL AND ECONOMIC FEASIBILITY 41

QUALITY CONTROL RECOMMENDATIONS 47

REFERENCES

APPENDIX A Resumes of Work Team

APPENDIX B List of Draft Documents Reviewed

SUMMARY

DNRC contracted with Aquoneering to review the process of preparing water reservations for conservation districts. The work products reviewed were in preliminary stages of development to assist in developing correct and complete applications. This review was done before completion of the applications to lessen time needed for modifications. The review included study of the credentials of the staff and their methodologies used to prepare the applications. We found that the eight team members working on this project are well qualified for the work at hand. They are a well educated group that seem to be working together as a team. Each of the members seem to recognize their limitations as well as their strengths. We conclude that the team has the capability to complete the water reservation applications completely and correctly.

The approach for this work effort was to review the field work, working files and summary sheets of five typical projects. We compared the conclusions with reasonable or expected answers. The five typical projects were selected by DNRC staff for review. This consultant observed the field inspections for these five projects. We then reviewed the draft files representing the design and feasibility determination prepared for each of the projects. Deviations from the expected results were then investigated and recommendations made to DNRC staff for alternative approaches. Department procedures were compared against standards and procedures used by this consultant and those published standards available in the literature. Documents, such as the SCS "Irrigation Guide" and the USBR "Project Planning and Loan Application Guidelines" were helpful in this review process.

This consultant found the field soils work to be well done and accurate. Our recommendations relate more to the feasibility or design step. It is recommended that the soil scientist refer to the SCS Irrigation Guide in determining AWC and other soil related parameters used in design. The application document should clearly state that additional soils investigation is warranted before a final design is completed. This investigation should include laboratory analysis of SAR, settling volume and gradation. If drainage is questionable, deep holes should be augured and a test made to determine hydraulic conductivity of the deeper soils. A drainage investigation is certainly warranted in the glacial till areas of Eastern Montana for intermittent irrigation. Infiltration rate testing is recommended where infiltration rates are marginal. We conclude that the field investigation conducted by the DNRC soil scientist does improve the accuracy of the water reservation applications and is complete and correct.

A screening procedure was developed and refined to select those projects with the greatest feasibility. The procedure included

both office screening and a field visit to each site. The field visits are a time consuming process. These visits, however, add considerably to the accuracy of the work. The visits have been more comprehensive than previous water reservation application efforts.

Comprehensive computer aided models were used to design and cost the projects such that they could be screened for inclusion in the reservation application. The output summaries of the design for five selected projects were reviewed by manual calculations and compared to typical answers that might be expected. Many of the calculations and assumptions found in the AutoLISP programs and spreadsheets were checked, using the original code from floppy disks. An exhaustive review of every detail and equation used in the model was not intended as a part of this scope of work, however. Recommendations include formatting changes, corrections of minor errors in equations, and additional documentation of summary results. The engineering concepts were found to be sound.

Using AutoCADD and spreadsheets is an efficient way to design irrigation projects. The staff of DNRC have made tremendous progress on this ambitious undertaking. The programs will be a valuable engineering tool as they evolve and are used by others. The concept is especially valuable in repetitive designs making up a water reservation application.

The approach to financial and economic feasibility is based on a probability that an irrigation project can repay its costs given varying yields and prices for alfalfa and small grains. The DNRC work effort includes a price forecasting model and alfalfa age versus yield relationship. Review of the output from the price forecasting model indicates that prices fluctuate considerably, verified by observation of historical data. This consultant concurs with price forecasting model approach as it more accurately portrays the risks of the "real world" market. However, we believe that the nature of water reservations are such that the feasibility cutoff should be liberal with the "probability of success" approach. We do recommend inclusion of a return to management and equity in the accounting of costs. Other inputs values and results seemed to be within expected ranges.

Specific recommendations and suggestions evolved out of earlier review efforts that are not reported here. Quality control measures are suggested for all applications. Our common goal is a correct and complete application. A high priority quality control measure would be review of each project by an experienced staff member who has not worked on that particular project. Quality control can also be accomplished by extracting key values throughout the spreadsheets and comparing them to expected values. The individual landowners are another potential source of input after the projects are presented to them.

INTRODUCTION

PURPOSE

The DNRC water reservation staff is presently assisting 18 Conservation Districts with water reservation applications. The 18 districts cover a large drainage area in the middle Missouri Basin, extending from Canyon Ferry Dam to Fort Peck Dam. The department's staff is charged with producing correct and complete applications for each of the districts. The Montana Environmental Policy Act requires preparation of an environmental impact statement (EIS) for actions of state government that have the potential to create significant environmental impacts. After the EIS is complete, DNRC will publish a notice and receive written objections to the reservation applications. If the Department determines that the objections are valid, a formal contested case hearing may be held.

It is recognized that the Department must be able to comment on the need for any requested reservation in the basin during a contested case hearing. The Department must remain independent of the Conservation Districts (CD) in this hearing, even though Department staff assisted in the preparation of the applications. The purpose of this work effort is to prepare for representation of the interest of the CD(s) during the expected contested case hearings. To do this effectively, the CDs' representative must be assured of the competency and objectivity of the Department staff, the accuracy of the methods employed in preparing the applications and the adequacy and

correctness of the final applications. The review described in this report is a step towards developing the background information and knowledge needed to represent the CD(s) at a contested case hearing.

SCOPE OF WORK

Obviously every application cannot be reviewed in detail with the limited resources available. The approach for this work effort was to review the summary sheets of five typical projects for reasonable or expected answers. Deviations from the expected were then investigated and recommendations made to DNRC staff for alternative approaches. The review included study of the credentials of the Staff and their methodologies used to prepare the application. Department procedures were compared against standards and procedures of this consultant and those published standards available in the literature. Documents, such as the SCS "Irrigation Guide" and the USBR "Project Planning and Loan Application Guidelines" were helpful in this review process.

The five typical projects were selected by DNRC staff for review. This consultant observed the field inspections for these five projects. We then reviewed the draft files representing the design and feasibility determination prepared for each of the projects. Specific recommendations and suggestions evolved out of this initial review effort. Quality control measures are suggested for other applications as a result of this review. Our common goal is a correct and complete application.

STAFF CREDENTIALS

PROCEDURE

A team of eight individuals has undertaken the task of developing water reservation applications for the 18 CD's. The team members are under the direction of John Sanders. They are identified as follows:

Name	Area of Expertise	Education	Registration
Timothy M. Byron	Soil Science	M.S., 1984, MSU	
Denise K. Deluca	Hydrologist	M.S., 1987, MSU	EIT
Daniel E. Dodds	Resource Economics	Ph.D., 1980, UW	
Bill Greiman	Ag Engineering	M.S., Pending, MSU	
Stephen R. Holnbeck	Hydrology/Hydraulics	M.S., 1980, MSU	PE, PH
John C. Sanders	Ag Engineering	B.S., 1976, UW	PE
Mark D. Shapley	Geologist	M.S., 1985, UM	
John E. Tubbs	Resource Economics	M.S., Pending, UM	

Seven of these individuals were interviewed during the week of June 13th in the offices of DNRC. Denise Deluca was interviewed on October 12 as she joined the team after the initial interview. The experience and background of all eight team members was reviewed. A resume was obtained from each member for reference as shown in Appendix A. The team members were then asked to summarize their technical approach. Discussions were encouraged regarding special problems and considerations, methodology, and interaction among the team members. Any first drafts or technical information was obtained, as it had progressed to that point in time. This information was utilized in the assessment of staff credentials.

FINDINGS

All members of the team are well educated; most with a Master of Science in their field of interest. The team also has access to a much larger staff within the whole of DNRC. Nearly all technical questions can be resolved "in house," given the time and resources to address the question. Experience levels vary within the team as it relates to irrigated agriculture. Tim Byron is gaining irrigated land classification experience with this project. His knowledge and experience with soils is more than adequate to identify limitations that would make them infeasible to irrigate. Denise Deluca is gaining experience with the hydrology of Eastern Montana watersheds. She is familiar with computer modeling of both urban and rural runoff relationships. Denise has worked with western irrigation and plant/soil/water relationships. This experience was used in

determining the water availability for the projects investigated in this project. Dan Dodds has extensive experience with agricultural economic problems and theory. The stochastic model approach to prices for alfalfa, small grains and alfalfa is an example of Dan's extensive knowledge of computer modeling and statistics. Dr. Dodds has some experience with enterprise studies or actual working farm budget analysis in Montana.

Bill Greiman has extensive experience in the nuances of irrigated agriculture. Much of this experience was gained when working for an equipment sales company and on Peace Corps service projects. Bill has gained considerable experience with the water reservation process in past years, primarily working for the Lower Yellowstone CD Development Committee. Bill has gained a good understanding of farm budgets and on-farm finance, refined during his thesis work.

Steve Holnbeck has developed considerable experience in all phases of applied hydrology and hydraulics. Steve has developed a stochastic approach to sizing reservoirs on ungaged streams. His knowledge of streamflow statistics and water right nuances will be helpful in determining water availability on those streams with records. John Sanders has considerable experience in the field of irrigation design. Much of this experience was gained as a sales engineer for an irrigation equipment dealer. More importantly, John has seven years of involvement in the water reservation program. Mark Shapley is gaining experience in evaluating the potential of various aquifers for groundwater supply throughout Montana. Mark works closely with

other knowledgeable hydrogeologic professionals in state and federal government. John Tubbs has gained experience in various aspects of cost-benefit analysis of water resource projects. John, like Dan Dodds, has a good understanding of statistical analysis and stochastic modeling. John has worked with on-farm enterprise studies and budgets in past projects, including the upper Missouri reservation applications.

This consultant found that the eight team members are well qualified for the work at hand. They are a well educated group that seem to be working together as a team. Each of the members seem to recognize their limitations as well as their strengths. We conclude that the team has the capability to complete the water reservation applications completely and correctly.

METHODOLOGIES

PROJECT ORGANIZATION

The following paragraphs describe the interrelationship of the work team, the record or file process of individual projects and the process of project selection or elimination. The adage, "Logical first - Physical second" seems to aid project management and its application was examined. Application of other project management techniques were reviewed by this consultant as well.

John Sanders is the project manager for preparation of water reservation applications. John acquires labor resources from his teams members as the projects evolve. All members have other responsibilities to DNRC projects. Only two of these team members, Bill Greiman and John Sanders, are committed to water reservation applications full time. A third full time hydrologist position has recently been filled by Denise Deluca. Tim Byron has worked much of his available time on this project, although he is not assigned full time. Bill, Tim and John Sanders have conducted the majority of the field investigations, with Bill and John trading off trips to the field. The rest of the team performed the analysis primarily using published information in an office setting.

Interest in the water reservation process was generated by contacting over 6,000 individual landowners through the 18 conservation districts. Between 175 and 200 potential irrigation projects evolved

from second responses to the questionnaires that were sent out. A file was established for each potential project and was given a two letter and three number code. Several forms were developed for field work and project status, included in each file. Computerized data base techniques were used to track individual project status. A typical file includes the following information:

* Water Reservation Landowner Status Sheet
* CD Water Reservation Questionnaire
* Resource Inventory Form
* Soils Information Form
* Storage Site Information Form
* Environmental Field Checklist
* Togographic and Soil Survey Mapping
* Water Availability Analysis
* Irrigation Design and Cost Summary
* Photos of Project Areas

The organization of the files was found to be logical and consistent. Checklists and other aids used internally should foster the correct and complete analysis of the feasible projects to be included in the application request.

A screening procedure was developed and refined to select those projects with the greatest feasibility. The procedure included both office screening and a field visit to each site. The field visits are a time consuming process. These visits, however, add considerably to

the accuracy of the work. The visits have probably been more comprehensive than previous water reservation application efforts; a plus for this effort.

The screening process started with a cursory examination of physical water availability. Steve Holnbeck was responsible for surface water availability and Mark Shapley examined the potential for groundwater availability. Both are difficult tasks because of the lack of detailed information on water resources in smaller drainages and lessor developed areas. If the water was found to be available, the project progressed to an examination of soils. This was done by Tim Byron, using existing SCS soil surveys and previous DNRC land classifications. If the soils exhibited those characteristics feasible for irrigation, the project was checked by John Tubbs or Bill Greiman for its chances of economic feasibility, primarily from a common sense standpoint. Successful projects then progressed to a field review.

Each owner was contacted for an appointment to visit the potential project. Tim Byron observed the surface of the soils and augured one or more holes to verify the published soil survey information. Bill Greiman and John Sanders observed the lay of the land, diversion points and obtained other information necessary to design the irrigation system. The level of detail could be defined as "a reconnaissance investigation" by USBR standards. After the field visit, the project layout was developed using the information available. This process does not provide details for construction but

allows calculation of an opinion of costs. The goal of the work team was to develop costs would be within +/- 25 percent of actual costs should the project be constructed as planned. The general intent of the work process to screen projects for inclusion in a reservation application, not to provide a design suitable for construction.

The final step in the screening process is to determine if the project is economically and financially feasible. This was accomplished by comparing project costs with expected benefits from irrigation. The procedure and models used in this analysis were developed by Dan Dodds, Bill Greiman and John Tubbs. Use of the HKM models and spreadsheets developed for the upper Missouri applications were also used, primarily as a comparison.

The project organization and management were found to be of a high level by this consultant. The progression of the projects through the screening process was logical and well organized. The five reviewed files were properly organized. Documentation was adequate but additional documentation is always helpful.

WATER AVAILABILITY

Investigations of surface water supply are based on physical rather than legal water availability. The reasons for this approach are documented in write-ups intended for the application and are only summarized here. Essentially, it is argued that water right claims and permits are often over-stated and do not account for return flow and reuse of water within the stream system. The depletion and

diversion quantities of any given permit or claim are dynamic and constantly changing. This change is due to management response, change of ownerships, different crops from year to year, changing economic factors, climatic factors, and rainfall to mention a few. Accounting for all water rights of record does not represent the true amount of water available in a drainage. Physical availability is judged to be an upper limit of water available for reservation in a drainage. Legal water availability will be considered during the anticipated contested case hearing(s).

A significant amount of the reservation requests involve stored water. Storage is necessary to develop the water supply in water-short basins. Many of the applications are for dams and reservoirs on smaller, ungaged streams. Since records are not available to operate the reservoirs, synthetic techniques are used to estimate streamflows. It was assumed that most drainages, many subject to over 100 years of historical development, will be short of water from July through September. Flows in these months were bypassed through the reservoir and not stored. The reservoir must be sized to provide water at least 8 years out of 10 to irrigation. These storage needs were determined using a computer model called a Reservoir Simulation Yield Model based on a stochastic approach to streamflows. A detailed discussion of this model is presented in separate reports and is not duplicated in this report.

Many requests involve a direct flow diversion without storage. DNRC has received a statistical summary of streamflow gauging records as

developed by the USGS. If the application request is on a major stream near one of the gauging stations, these records can be used directly. A check was made of the demands, based on depletion of WRS mapped acreage, for existing irrigation downstream to the next major tributary. Documentation of this analysis was found in the files submitted for the five typical projects. The 80 percent exceedance frequency is typically used as the amount of water available for feasible irrigation diversions. In the case of ungaged streams, regional or empirical techniques were necessary. Methods included those developed by Potts (1980), Missouri River Basin Commission (MRBC) (1969), and Parrett and Omang (1984). Typical input parameters were drainage area and annual precipitation. Annual values were distributed on a monthly basis as according to runoff patterns from nearby gages with similar drainage characteristics.

Groundwater was investigated as a source for all applications failing to meet the criteria for surface water availability and for those applications expressing the intent to reserve groundwater. Potential aquifers were identified using published information, such as well logs, hydrogeologic reports and geologic mapping. Unpublished information, available in DNRC and MBMG files, was another source of information. No field work, such as drilling exploratory holes or geophysical investigations, could be completed due to the high cost of these investigations. The aquifers must exhibit a sufficiently high transmissivity in other area wells to yield sufficient water for an irrigation well. The next step was to examine the expected water quality from the aquifer. Again, published information was used

including MBMG open-file mapping of regional groundwater chemistry and data from the MBMG groundwater information control data base. Groundwater quality standards must meet those published in the "Montana Irrigation Guide," which evolved from numerous other standards accepted for irrigation. Groundwater quality is a problem in many areas of the middle Missouri River Basin.

Yields from wells must be large enough to support irrigation. Well yields were estimated by examining nearby well logs, talking to area drillers and inference from geologic knowledge of the aquifer. Wells that are not expected to yield sufficient water, assumed by this consultant to be at least 100 gpm, are dropped from further consideration.

Two additional groundwater screening checks were made. If the potential groundwater source shows indications of over-appropriation, the groundwater source was not considered further. Economic feasibility was checked using by using a spreadsheet matrix which established a maximum drilling depth based on pumping lifts and flowrates. Capital costs were amortized at 4.6 percent for 30 years and added to pumping costs at $0.04/KWH and compared to a $75/acre maximum cost. If depths to the bottom of the aquifer exceeded the allowable depths, the groundwater option was not considered further.

SOILS INVESTIGATIONS

The suitability of the soils for irrigation is determined from land classification of the soils. Class 1, 2 and 3 lands are considered

to be irrigable and Class 6 lands are not. The land classification system has evolved from other standards as explained in draft sections of the application (see listing in Appendix B). Where SCS soils survey mapping is current, each soil series or map unit was placed into a class. Soil deficiencies would downgrade the soil from the Class 1 depending upon the extent of the limitations. The map unit ratings were reviewed by SCS soil interpretation specialists and their suggestions were incorporated into the final tables. The land classification was not used to determine yields or payment capacity as the USBR does in their planning.

Some areas do not have current soil surveys as of yet. These areas required use of the DNRC reconnaissance mapping or other sources such as aerial photos, topographic mapping, geologic maps and local SCS field office surveys. All of this information was further refined and checked during the field investigation. Deep drainage holes and chemical analysis of samples were not included in this soils investigation.

Field procedures are designed to verify existing information and are intended to be a reconnaissance land classification effort. The soil scientist developed information for the ag engineer to utilize in the design of the irrigation system, usually from several sources. The dominant soil types within each field were characterized by the soil scientist by observation and feel. Subsurface characteristics were determined from 3-inch hand auger borings to a depth of 5 feet or an impenetrable material. Stream cutbanks, road cuts and other soil

exposures were examined to provide additional information about profile characteristics. Areas affected by salinity and alkalinity were identified in the field, primarily by observation of telltale vegetation and surface characteristics of the soil. Chemical analysis of the soils was not completed. Irrigation feasibility is also assessed by noting the performance of irrigation systems operating on nearby lands.

The land classification was transposed to project maps at a scale of 1:24,000. If a system contained more than 10 percent of true Class 6 land, the location of the system was reconsidered or the system was excluded from the project. As discussed later, some types of Class 6 land are acceptable under continuous move sprinkler irrigation as the soil deficiencies can be accommodated by design or the land is feasible to reclaim. Inclusion of some Class 6 land in center pivots is necessary, in many cases, to irrigate the better soils within the project area. Parameters for intermittent irrigation design were noted for each map unit, specifically, soil water holding capacity and maximum intake rate. We understand that these parameters are not used in the present version of the continuous irrigation systems design, e.g., as center pivot sprinklers. Low intake rates may affect cost and maximum system length and should be considered.

IRRIGATION DESIGN

Each project considered for inclusion in the CD application is designed such that the major features can be sized and priced. A goal is to develop a cost estimate that is accurate to +/- 25% if

construction were to take place immediately. The goal of the design is to develop costs by which the economic and financial feasibility can be determined. The design is not intended to be detailed enough to construct the system, however. This word of warning should be incorporated into the reservation documents

The design tools used by DNRC staff incorporate the use of the microcomputer and supporting software. This method utilizes computer aided design (AutoCAD rel. 9.0, 1987) and a computer spreadsheet (Lotus 123, rel. 2.01, 1987) to develop design summaries and costs for irrigation projects. Again, the details of the approach are presented in technical papers and are only summarized.

AutoCAD can keep track of distances and areas as components of an irrigation system are quickly drawn with the aid of a digitizer. These numbers are attached to the related entity as attributes and later extracted into a spreadsheet program. The irrigation layouts are developed using USGS quad maps as a base. The drawings are produced at a scale of 1:24,000 or 1" = 2,000', utilizing a digitizing tablet for input. The first step is to gather information on the soils and consumptive use requirements of the system. The template drawing is then loaded into AutoCAD and the AutoLisp programing files are loaded as a subset of the basic AutoCAD program. The quad sheet is attached to the digitizer and the tablet is calibrated to the quad. An AutoLISP program called INT is then run from the command line. This allows the designer to initialize the program and input basic design information. The user then enters the peak consumptive use,

the soil water holding capacity, total crop consumptive use, the net irrigation requirement, maximum soil intake rate and the length of the required 3-phase power line construction.

Since soils information is important to the layout of an irrigation system, the next step is to transfer soils boundaries to the drawing as a layer. The area of each land class is determined using the AutoCAD AREA command and the soil attributes are entered. Next the irrigation system layouts are drawn, with four choices as to type of irrigation. Center pivots are drawn using three points on the outer edge of the irrigated area. Hand lines are drawn as a polyline entity. Wheel lines are drawn as rectangular polyline entities. Flood irrigation is drawn as an area with polylines and a header ditch is drawn at the top of the field. After the layout is complete, the irrigation attributes can be added with AutoLISP programs and entity selection. Pipe layout and dams can be added at this point, again with attributes attached. A PNODE AutoLISP program then steps through the hydraulics of the pipeline design. The attribute information is exported to files that can be read by spreadsheet templates for cost estimating and financial analysis. These spreadsheets can then be printed for summaries of the design.

Many design assumptions were made in the structure of the program. The validity of these assumptions is discussed in the Typical Project Review section later. Many of these assumptions are a matter of engineering judgement for the design situation at hand. The programs are not intelligent in that they do not make design decisions. The

program should be completely understood, as it does use default variables in engineering calculations that could give erroneous results if not changed for differing conditions. The program does not have extensive error trapping at this stage of development. The program is not user friendly as a very specific procedure must be followed in the data entry. Otherwise, errors may show up unexpectedly in the summary sheets. Persons using the programs should have a good working knowledge of irrigation design, as well as AutoCADD and Lotus 123 programs.

FINANCIAL AND ECONOMIC FEASIBILITY

The method used to determine financial and economic feasibility is based on probability that an irrigation project can repay its costs given varying yields and prices for alfalfa and small grains. This method differs from the more common cost/benefit ratio analysis used in the Upper Missouri River applications. Spreadsheet models of farm enterprise costs were developed using specific input variables for different climatic areas. Prices received for alfalfa and small grains were based on a stochastic analysis of historic data. Several variables were statistically regressed and a model was developed which mirrors the fickle nature of prices in the market. The price forecasting model utilizes statistical techniques with numerous dependent variables as described in the "Economic Analysis of Granite County Conservation District's Proposed Irrigation Projects" report. Many scenarios were ran and the data was reduced to a probability table used by the summary spreadsheets.

Two other variations from the upper Missouri River applications are noted. First, harvest costs for alfalfa were tied to yield and number of cuttings instead of the uniform value presented in the upper Missouri applications. Other enterprise costs for both alfalfa and grain were also tied to yield. This was done by spreadsheet and presented as a matrix for alfalfa and small grains. The second variation is an alfalfa yield relationship based on consumptive use and time after establishment, instead of just consumptive use. The early and late stand age times show a significant reduction in yields. This method of analysis more accurately reflects the reality of changing market conditions.

The difference between financial and economic costs depends on the use of discount rates (real rate of return allowing for inflation) and market (bank) interest rates. The term of the amortization of capital is also a factor. The feasibility of the project can be assessed from a cash flow basis and a public benefit basis in this manner. This procedure appears to be similar to the upper Missouri approach.

FIELD INVESTIGATIONS

This consultant traveled with John Sanders and Tim Byron during their field review of five projects July 13,14 and 15, 1988. Field data collection procedures were observed during this trip. The first order of business was to locate the headquarters of the owner or operator of the proposed project. This was accomplished using USGS quad maps and owner supplied directions. Once the owner was contacted, the project could be easily located using USGS 7 1/2 minute quad maps and aerial photos. Both John and Tim were familiar with reading maps and could accurately locate themselves using topographic features and drainages.

The project was briefly reviewed with the owner, looking over the maps, usually with the field to be irrigated in view. The soil scientist and engineer would travel the field and gain an overview of a potential project layout. Special considerations and problems were then jointly discussed. The engineer and soil scientist would then proceed in separate directions to complete their work. The soil scientist would travel to representative mapping units (previously identified in the office) to auger holes and observe the general surface features of the field. The auger cuttings were laid out on the ground near the hole in their order of removal. The soil was textured by wetting and feel and was checked for effervescence by

adding sulfuric acid to a sample. The field form was then completed for the hole. This consultant found the soils investigation to be adequate for reconnaissance design of an irrigation system. The following comments are offered for future field work. The breakdown of the log into just two layers, i.e., topsoil and subsoil, may not adequately describe all of the horizons in the profile. The percentage of clay is difficult to report on a field form without the benefit of a laboratory hydrometer analysis. Two important factors are difficult to determine without additional investigation: 1) salinity and alkalinity and 2) infiltration rate of the soil under sprinkler irrigation. The former requires sampling and chemical analysis in a laboratory. The latter requires simulating application of water with a rainmaker setup and observing runoff. Also, deep auger holes, with in-place permeability testing, are necessary to flag potential drainage problems. It is recognized that these procedures are beyond the scope of work allowed for this project and would normally be included in a feasibility level design. It is also recognized that many private projects are developed with even less soils information than used in this analysis. The soils field work is certainly an improvement over no visit at all and will serve the purpose of providing more specific parameters to design an irrigation system.

The work product for the water reservations was intended to meet a reconnaissance level but several components were completed at a feasibility level. Reconnaissance estimates are the earliest approximations of costs for preliminary evaluation of a project. They are obtained simply to determine if the project should be investigated

further. Charts, graphs and other shortcut procedures are used to obtain estimates of costs, with only a minimum of attention to layout and design details. Feasibility estimates are more detailed and exact, resulting in a quantities and extended costs to develop a cost estimate. Feasibility estimates are usually the basis for financial aid for a project or to determine public policy.

The following paragraphs will discuss the engineering field procedure. The ag engineer would usually proceed first to the proposed point of diversion. The elevation was noted on the field form, using the 7 1/2 minute quad as a source of information. Accuracy of this elevation is probably 1/4 of the contour interval or five feet, given a 20 foot contour interval. This level of detail is acceptable for a reconnaissance study, compared to differential leveling needed for final design. Other pertinent topographic information is noted on the form, including the high point of the field. The field form also includes information on the location of the diversion, physical information and the streambank stability. The detail of the inspection and measurements should be adequate to design a cursory diversion structure and allow for costs of stabilizing the streambank for surface diversions.

The engineer then travels around the periphery of the field to be irrigated, observing potential physical features and obstructions. These obstructions were roughly located on the quad map for later reference in the preliminary design. This procedure was adequate for reconnaissance purposes. In the final design of a center pivot

system, these obstacles must be surveyed accurately before layout. In rougher areas, topographic constraints were identified and engineering judgement applied to determine if a sprinkler system could traverse the draw, hill or other constraint. In a final design, these constraints would be accurately surveyed and the system laid out to span draws, allow clearances for bow trusses, overhang spans, etc. In many cases, earthwork may be necessary and quantities must be computed to define costs more accurately. However, engineering judgement is adequate for water reservation screening.

The proposed route of the conveyance system was traced in the field, whether a pipeline, canal or a field head-ditch or equivalent (such as gated pipe). The engineer noted on the field form any potential construction or maintenance problems that would seriously impact costs. In conjunction with this task, the engineer sketches a preliminary system layout on the quad maps. Major features are identified, such as the point of diversion (POD), need for pumps, canal and pipeline routes and approximate boundaries of the irrigation system. Finally, the location of the nearest 3-phase power line was noted. This field procedure was found to be adequate for the five projects inspected. We note that the presence of rock excavation may be difficult to determine without drilling or backhoe pits and could increase costs significantly. The engineer has to rely on geologic factors and surface clues in this case.

If the project involves a potential dam and reservoir, a specific inspection of the dam site was conducted. Typically, only the most

basic information was collected in the field. The information collected, although less intensive than for the irrigation layout, does satisfy the requirements of a reconnaissance study. Accurate construction costs require detail investigations and design.

The location of the damsite was noted on the forms. The embankment height and length were determined using handlevels and distance measuring devices. A spillway location was noted as well as special considerations that are obvious, such as easily erodible soils. The pool area was described, including the potential for flooding of man-made features. The downstream flood hazard during a dam breach was assessed on a cursory basis. The potential geologic hazards for both the dam and the reservoir were assessed by a checklist, based on surface observations only.

The field investigation also included a check of obvious environmental impacts that may occur from irrigation development. Cultural resources and biological resources were inventoried, if discovered during the field investigation. This checklist included prehistoric remains, historic sites, riparian communities, wetlands, nesting sites, waterfowl habitat and observed wildlife. This procedure is concurrent with the level of detail of the other field investigations.

In summary, the field investigations are adequate to support reconnaissance designs. Dams, rock excavation for canals and pipelines and surface water intakes on large streams are more complex to design and require expensive geotechnical investigation. This

consultant recommends that the reservation application writeup advises the owner(s) that additional, feasibility level, detail should be obtained for these particular features. Significant changes can be incorporated into 10 year reviews of the application. The project can be dropped if additional information shows that costs exceed benefits.

WATER AVAILABILITY

Analysis of water availability has been completed by DNRC staff for the five projects reviewed. Two of the projects have proposed storage and reservoir operation runs have been made for these projects (GL-31, Big Sky Colony, Inc. and GL-101, Glendale Colony, Inc). The other three projects depend upon direct flow diversions from Cut Bank Creek and the Two Medicine River. The water availability is based on a comparison of the project's acreage compared to acreage that could be irrigated given an 80 percent chance streamflow. The 80 percent chance flows were developed from data from a representative upstream gage. The water availability is based on an assumption that the entire stream can be diverted for irrigation. DNRC staff recognize that many factors may preclude this scenario but it does serve to place an upper limit on water availability for irrigation.

The effect of a proposed diversion for a typical irrigation project was estimated by a spreadsheet model. The model assigns efficiencies to the conveyance and on-farm systems that are typical of newer irrigation practices. Return flow patterns for surface water and groundwater were estimated to establish the timing of the return of diverted water to the stream system. The model can accommodate

several choices of crops and irrigation system types. The selection for this analysis was alfalfa with a net annual irrigation requirement of 1.62 acre-feet and a canal/continuous move sprinkler system. The critical time for diversion of water is August when temperatures are hot and flows are low. The results of this model show that each cfs of available water will supply 118 acres of land under sprinkler irrigation. This consultant has reviewed this determination and has found it to be reasonable.

Two of the projects are located on Cut Bank Creek, i.e., GL-11, Alan Anderson and GL-221, Dan Henderson. Extended flows for the gage on Cut Bank Creek near Cut Bank show 80 percent chance flows of 114 CFS in July, 35.4 CFS in August and 40.2 CFS in September. Using August flows, the potential exists for 4,130 acres of irrigation. These flows are derived from a 1937 to 1986 base period but are not corrected for existing depletion levels. Mr. Gary Smith, Public Works Director for Cut Bank reported that significant acreage has been developed by center pivot irrigation above Cut Bank in recent years. Flows corrected for present day depletions will likely show significantly lower values. The 9.6 CFS requested in these two reservations will probably require most of the water physically available in the stream. This is a judgement made from the very low flows observed this summer and experience with the Cut Bank application. Water availability may be marginal, particularly if instream flow reservation requests have a similar priority. Water availability is adequately addressed for the reservation application

but should be addressed in greater detail before hard earned dollars are spent.

One of the projects proposes to divert water from the Two Medicine River, i.e., PO-421, D Bar L Ranch. Assuming the three pivot alternate, the project will divert slightly over 4 CFS. Two upstream gages have records. One is upstream on the Two Medicine River and has been in operation since May of 1977. This gage record was extended in the 1937-86 Base Period provided to DNRC by the USGS. The record shows 80 percent flows of 27 cfs in August. The second gage of interest is on Badger Creek below the Four Horns Canal diversion. Extended records show August 80 percent chance flows are 39.5 CFS, most of which would probably reach the Two Medicine River. During the project inspection, the flows in the river were 30 feet wide and 1 foot deep in the center, flowing about 0.75 FPS. Assuming a flow area of 20 ft^2, the discharge is estimated to be about 15 CFS. This occurred in an extreme low flow year (1988), indicating that enough water is physically available for a 4 CFS diversion. This consultant concurs with DNRC staff in that adequate water is available for the reservation application.

Concerning the primary reservoir identified in GL-101 (Glendale Colony), a final operation study was included in the file. The summary sheets indicate a need for 909.7 AF of active capacity to provide 201 AF of water for irrigation. This stream is intermittent with a sizeable reservoir above, which also stores water. The dam is planned at its topographic potential, 1,008 AF, which allows for dead

storage and sediment storage capacity. We believe that the assessment of the size of reservoir is correct given the intermittent flow nature of the stream.

The GL-31 (Glendale Colony) final reservoir operation study shows that the 120 AF reservoir as planned will provide 45 AF of storage on a firm yield basis. The input and output files were reviewed. This stream was not flowing during the inspection and appears to flow only intermittently. Given the intermittent nature of the runoff, considerable carry-over storage will be needed. We concur with the analysis.

SOILS ANALYSIS

This section discusses each of projects with respect to the soil analysis as follows:

* Project GL-101, Glendale Colony: Two holes were augured, primarily to verify SCS mapping units. The predominate soil type is mapped as a Fairfield Loam, with an assigned land class of 1. The log of the field investigation in this map unit shows a deep loam soil, with good structure, water holding capacity, and permeability. Field inspection of the auger cuttings by this consultant indicate that the soils interpretation is correct. The dryland crops were productive on this field, considering the dry conditions. These soils will be productive under irrigation. The heavy texture of the subsoils, typical of glacial till

origin, may require special drainage considerations with intermittent irrigation. The soils would provide better drainage with continuous move sprinkler irrigation, such as center pivots.

The second hole was augured in a Kochia Loam map unit, near the left abutment of the dam. This soil was logged as a silty clay loam texture, again verified by this consultant's observation in the field. These silty soils appear in and adjacent to the channel bottoms, typically, and are not predominate in the area. As discussed later, the existing dam was constructed from silty soils, which are a very poor construction material from an engineering standpoint. These soils may result in additional cost for the dam foundation, internal drainage and spillway.

* Project GL-31, Big Sky Colony: One hole was augured on a field located adjacent to a potential reservoir. The SCS soil series name is Ethridge Silty Clay Loam and is mapped as the predominate soil on the bench. A land class was not noted on the soils forms but was shown as class 3 on the irrigation design. Based on the land class specifications and the logs, DNRC may consider placing this soil in Class 2. This would downgrade the soil one class for potential subsurface salinity problems and wind and water erosion potential. Sprinkler irrigation negates any other potential limitation, such as slope. The AWC is shown as 7.5 inches for 4 feet, compared to 7.8 inches shown in the Irrigation Guide. The soils are shown in a "D" sprinkler intake group in the guide,

acceptable for hand line sprinkler irrigation. We estimate that the infiltration rate will exceed 1.5 inches/hour after 30 minutes of wetting, using SCS equations developed for the 1.0 inch/hour intake family. This calculation supports the 1.0 inch/hour maximum rate shown in the soils portion of the summary sheets.

* Project GL-11, Anderson: Three holes were augured in this area, primarily in the west half of section 28 and 29. All the holes exhibited a silty clay loam to clay loam texture on the surface. Considerable cobble existed in many areas of the field. The lower portions of the potentially irrigable area, particularly next to Cut Bank Creek, do exhibit signs of alkalinity but the upland areas were dryland farmed and appeared productive. Much of the area was determined to be Class 6, probably due to salinity and alkalinity problems. The western portion of the area investigated, mostly in section 30, was kept in a Class 6 category. Presumably this was done based on SCS or DNRC classification. However, many of these same soil series are irrigated by an existing center pivot with no obvious reduction in yield. It may be extremely difficult to isolate alkaline soils without detailed surveys and chemical analysis. The past soil surveys may overstate the problem in the upland area. However, based on the information available to the soil scientist, the logical decision was probably made. The infiltration rate was reported to be 0.5 inches/hour in the design. The infiltration rate will probably be between 0.5 and

0.75 inch/hour for these soils after 30 minutes of wetting. With a large center pivot, such as those proposed, there is potential for runoff at the outer end on steeper slopes. This may be a case where additional cost should be added to the pivot to allow for spray booms and flotation tires. This equipment will minimize the effect of runoff.

* Project GL-221, Henderson: One hole was augured to 45 inches until refusal due to gravel. The surface of the field has considerable cobble; enough to reduce the classification one level. The land was placed in a Class 2, which is correct in our opinion. This selection is based in part by observing that the ground is productive dryland farm ground. Most of the area is a Martinsdale soil series. The SCS Irrigation Guide shows a mid range AWC of 7.0 inches/4 feet, compared to a 8.7 value shown in the design calculation. The 7.0 value is probably more representative given the high percentage of cobble. The intake rate of these soils is shown as 0.5 inches/hour in the design. This consultant calculates that these soils will have an infiltration rate near 1 inch/hour after 30 minutes of wetting. The latter rate is acceptable for the size of center pivot planned; the 0.5 inch/hour will probably result in runoff.

* Project PO-421, D BAR L: Three holes were augured at three terrace levels; also verifying three soil survey mapping units. The lower terrace is mapped as an Ethridge-Ashbor unit, Class 2. The texture was logged as a Silty Clay Loam with auger refusal

due to gravel at 24 inches. The AWC was shown as 9.2 inches per foot on the design, compared to 6.7 to 8.4 in the Irrigation Guide. The lower value of 6.7 is probably more correct due to the gravel at 24 inches. The soil has an infiltration rate near 1 in/hour after 30 minutes of wetting. This is acceptable for center pivot irrigation.

The middle terrace is mapped as Pendroy Clay, Class 6, by the SCS and DNRC. The hole augured in the area indicated a texture of Silty Clay Loam or Clay Loam in the upper 36 inches. The lower portion of the hole was more clay in texture. The soils were determined to be irrigable in the application; a decision with which this consultant agrees. The soils around this hole are more typical of the Ethridge unit described above. The bench to the east does exhibit Pendroy clays. The very low infiltration rates exhibited by these soils would preclude sprinkler irrigation. This area was correctly eliminated from the design in the application.

The upper terrace is mapped as a Fairfield Gravely Loam. Since the hole could only be augured 36 inches, the field boring bears this out. The DNRC Land Class is 1 but the Class should probably be 3, due to a shallow depth to gravel and a high percentage of cobble. The SCS shows an AWC of 6.8 inches/4 foot compared to the 9.2 used in design. Again, the 6.8 is probably closer considering the shallow depth to gravel. The design shows a maximum infiltration rate of 1 inch/hour. The SCS shows a higher

rate (sprinkler intake group C and D), with cylinder infiltration rates of 0.5 inches/hour at 7 inches. We calculate an infiltration rate of 1.5 inches per hour after 30 minutes of wetting. This rate will accommodate center pivot irrigation without major runoff problems.

In summary, this consultant found the field soils work to be well done and accurate. It is recommended that the soil scientist refer to the SCS Irrigation Guide in determining AWC and other soil related parameters used in design. The application document should clearly state that additional soils investigation is warranted before a final design is completed. This investigation should include laboratory analysis of SAR, settling volume and gradation. If drainage is questionable, deep holes should be augured and a test made to determine hydraulic conductivity of the deeper soils. A drainage investigation is certainly warranted in the glacial till areas of Eastern Montana for intermittent irrigation. Infiltration rate testing using a portable pump, small tank (500 gallons) and part circle sprinkler is recommended where infiltration rates are marginal. This consultant concludes that the field investigation conducted by the DNRC soil scientist does improve the accuracy of the water reservation applications.

DESIGN AND COST ESTIMATES OF IRRIGATION SYSTEMS

A comprehensive computerized model was used to design the five projects that were reviewed by this consultant. The output summaries of the design for the five projects were reviewed by manual

calculations and compared to typical answers that might be expected. Many of the calculations and assumptions found in the AutoLISP programs and spreadsheets were checked as reported. An exhaustive review of every detail and equation used in the model was not intended as a part of this scope of work.

Each of the projects is critiqued in the following paragraphs:

* Project PO-421, D BAR L: Both a three pivot and two pivot layout were examined but the two pivot layout was chosen as more feasible. The IRRIGATION ATTRIBUTES section will be discussed first. Flowrates to the pivots reduce to 5.78 gpm/acre, a rate typical of center pivot design and one which will meet crop requirements. The "MIN-PR" heading is assumed to be pressure (in feet) at the bottom of the pivot, in the pipe, with elevation rise to the high point of the field. For pivot 1, the MIN-PR is shown as 108 feet. Assuming a low pressure spray system of 10 psi (23 feet), measured at the pressure regulator base, 12 feet of elevation lift at the pivot, 3 feet of soil over the pipe, 30 feet of friction loss in the sprinkler system (6" OD pipe), and 40 feet of elevation lift in the field, the MIN-PR is hand calculated to be 108 feet. This value agrees exactly with the reported value. The values for LABOR seem reasonable. Using the reported 15.3 inches of net irrigation requirement , and a 75% efficiency, the AC-FT value for 73 acres is 124.1 as compared to 125 reported. The value reported for PIVOT COST is reasonable

for a standard system. The values for the other pivot checked closely with hand calculations.

The DISTRIBUTION SYSTEM attributes are discussed next with respect to PO-421A, the two pivot version. The total dynamic head at the pump was calculated (using the reported MIN-PR) to be 271 feet at the pump, compared to 270 feet on the printouts. This is excellent agreement. The sizing and pressure class is correct. The costs for the pipe are close for an irrigation installation by a local, nonunion dealer, assuming no rock excavation. The ground elevations at the pipe nodes are printed, which aids review. Head or pressures truly reflects a hydraulic gradeline at the pipe. It is suggested that friction head be printed as ft/1,000 feet for the files. This could be accomplished by printing more of the spreadsheet. This information would help a reviewer check the hydraulics. The friction loss will fall into a range for most systems and an unusual number can be easily spotted. Error checking, in the form of acceptable ranges, could be incorporated into the program.

From a layout standpoint, it may be better to dedicate a pump, motor and pipeline to each of the pivots. The pipe would travel directly from the pump to the pivot point. This provides redundancy if one system goes down, reduces transient problems and results in a smaller pump, i.e. lower energy requirement for

the lower circle. This is a designer decision, however, and the reported layout is perfectly acceptable.

The PUMP ATTRIBUTES are discussed next. The horsepower requirements reflect a pump and motor efficiency of 0.75 and 0.91. respectively. The calculations were checked as correct. Nameplate horsepower of standard size motors should be reported in the IRRIGATION COSTS TABLE, in lieu of calculated horsepower. For example, an 85 HP load requires purchase of a 100 HP motor. This information exists in the spreadsheet and can easily be extracted. Nameplate horsepower appears to be used to calculate pump and motor costs. We would suggest allowing for a 5% overload in the selection of motors. The amount of overload should be much less than the 15 percent service factor as the higher altitudes result in less cooling ability. If not included, we would suggest including a 0.75 KW demand per 150 feet of center pivot hardware length for tower motor and end gun booster pump load.

* Project GL-221 and GL-222, Henderson: Review of the IRRIGATION ATTRIBUTES for GL-221 demonstrates that area and flow calculations are correct. The larger pivot may need a 8 inch pipe for the first 2 or 3 spans to reduce friction losses. This will increase costs for the sprinkler. The reported total costs are reasonable. GL-222 is similar as far as review comments. The comments for PO-421 also apply to these projects, e.g.,

presentation recommendations. The DISTRIBUTION SYSTEM ATTRIBUTES were checked and found to be correct.

* Project GL-11, Anderson: The IRRIGATION ATTRIBUTES show a flowrate of 6.0 gpm/acre, based on a peak consumptive use of 0.24 inches per day. Review of the AutoLISP program indicates a selection of PCU based on AWC in the soil. The SCS Irrigation Guide bases the PCU on application amount, which this consultant believes to more representative. It is probably better to reduce the flowrate on these soils, due to potential runoff problems from high application rates on heavy clay soils. Mining of soil moisture would be necessary in mid-summer with this plan. The other calculations were found to be correct.

Concerning the DISTRIBUTION SYSTEM ATTRIBUTES, the hydraulics and connectivity of the pipe check with independent calculations. A check of the totals of diesel costs compared to electrical costs shows diesel to be less, but electricity is selected. Judging from the equation that makes the selection in the spreadsheet, the reporting is not complete. Other costs enter into the selection of diesel vs. electric, of which the reader is not aware. Perhaps only electrical energy costs should be reported, based not on HP but KW DEMAND or GAL/HR of energy use.

Pivot # 2 is lower in elevation and requires less pressure than pivot # 1 to operate. The pump TDH was correctly calculated using pivot # 1 as the controlling system.

The PUMP ATTRIBUTES were checked as correct. The original files did not include a $10,000 cost identified in the field forms for bank stabilization. The corrected version included this value. The need for "Other costs" should be carefully checked in all of the files, particularly those with surface water diversion, highway or railroad crossings, dams, etc.

* Project GL-31, Big Sky Colony: The IRRIGATION ATTRIBUTES were checked and agreed closely with the reported values. An independent check was made based on 22.7 acres, 0.24 inches/hour peak consumptive use, a 65% efficiency, and 23 hours of irrigation each day. This calculation results in 172 gpm vs. the 166 reported. The small difference is probably attributed to a slight difference in hardware length. The check equation that we used is shown on page 51 of "Irrigation," Fifth Edition. All other values check closely.

The PUMP horsepower was calculated to be 8.05 vs. 8 reported: very close. Again the horsepower of the motor should be reported at the next available size of 10 instead of 8 for costing purposes. Costs are reasonable for a pump and motor of this size.

A relatively detailed profile was obtained at this dam site to check the dam template quantities but this information was not found in the file. If the profile is such that the dam is near

the maximum height, 50 to 60 feet from the abutments, the fill yardage will probably exceed 15,000 CY, verifying the 16,314 CY reported. This particular dam has a natural saddle that can be used for an auxiliary spillway and exhibits no unusual foundation or abutment conditions on the surface. Even with this help from nature, the feasibility of the dam is questionable, as correctly reported in the analysis.

* Project GL-101, Glendale Colony: Although wheel lines were chosen for this project, use of a center pivot system is a possible alternative. It is possible that the 1,008 AF reservoir would provide enough water for a 120 to 130 acre center pivot with an 80 percent chance availability instead of 100 percent. We understand that the applicant requested a sideroll system and that these requests were honored in preparing the application. The IRRIGATION ATTRIBUTES output was checked. The reported gpm is 7 percent higher than our check calculations. Using the equation referenced earlier, a need of 711 gpm is calculated as compared to 759 gpm reported. The difference is attributed to a need for a higher flowrate to accommodate dropping of wheel line sections in one portion of the field. We concur with the higher flowrate given the shape of the field. Pressure requirements may be reduced with the use of CDS nozzles. This option may be investigated if a detail design is initiated. The other values were found to be reasonable.

The DISTRIBUTION and PUMP ATTRIBUTES are straightforward and correct. The TDH calculations compared exactly at 180 feet. The horsepower (HP) should be shown as 50 in the IRRIGATION COSTS TABLE. Hours and costs are within reason.

The DAM ATTRIBUTES section was reviewed. The existing dam is breached and it may be possible to use the existing embankment in some way. If the entire embankment was replaced, it is estimated that the volume of material needed would exceed 30,000 CY. A value of 41,193 CY is reported, which is within reason for this trapezoidal shaped channel. The available materials are silty and are not a good material for dam construction. The auxiliary spillway will probably be large, judging from the 71 square mile drainage area. The USGS regional equations yield a 4,500 CFS flood with a 100 year return interval. The spillway will be difficult to hold in the deep, silty soils found in this area. It is likely that a feasibility study for a properly constructed dam will yield even higher costs that those reported in the DAM ATTRIBUTES section.

GENERAL COMMENTS

The following general comments are offered, specific to all projects. Perhaps a standard legend could be developed for the final presentations. Assumptions and definitions should be included in the format of the spreadsheets, probably in footnotes at the bottom. The CAD drawings should be overlaid on the quads when producing the final product. It is important to include supporting information and all

available computer output in the files; abbreviated computer output is difficult to review.

The IRRIGATION COSTS TABLES were reviewed and appeared to be correct and complete. The factors added to pipe, pump controls, ditches, etc. seem reasonable. The 10% O&M value for flood irrigation seems high but is intended to allow for land smoothing each year on leveled fields. One could easily argue for a 100 year life for reservoirs in the economic and financial analysis. The different assumptions for economic and financial analysis would clarify the table. The financial and economic extensions were assumed to be correctly developed within the spreadsheet and were not checked. The unit cost for LABOR does not appear in the sheet and should be included in the report. Some format changes and editorial work would probably clean the sheets up for a final presentation. There are a few misspellings, such as Peak Conc(s)umptive Use. In general, the summary sheets are much improved over earlier versions.

The concept of using AutoCADD and spreadsheets is an excellent one and the staff of DNRC have made tremendous progress on this ambitious undertaking. The programs will be a valuable engineering tool as they evolve. In time, user friendly prompts, additional flexibility and error trapping will add to the basic concept.

FINANCIAL AND ECONOMIC FEASIBILITY

The right to reserve water for future use carries with it the duty to show that the project is financially and economically feasible.

Feasibility was assessed with the aid of spreadsheets, used to make the many calculations involved in this process. The primary emphasis of this portion of the review centered on a feel for how reasonable the results were and not on the detail inputs and equations of the spreadsheets and models. Feasibility determinations are seldom absolute but do serve to compare projects, one to another, and generally assess a project's chances of success.

Accounting of each project's costs and benefits can be done in a variety of ways. The DNRC staff chose the enterprise method, closely paralleling procedures used in Montana State University Extension studies. The analysis includes two representative enterprises, alfalfa and small grains, irrigated crops which are common to the area. Past studies by this consultant have shown that two considerations are more sensitive than others in determining feasibility; prices received and crop yields. Two other assumptions are also sensitive in determining the benefit resulting from irrigated agriculture; return to the farmers equity (particularly land) and return to management. These values are difficult to assess as many farmers are willing to take minimal returns if their cash flow is adequate to provide a living for their families. DNRC recognized the sensitivity of feasibility to prices and yields and developed a more comprehensive approach. Previous, more simplistic, efforts assumed one average value, based on historic data, for prices received and yields. In reality, these values fluctuate considerably from year to year and are difficult to predict.

The DNRC work effort includes a price forecasting model and alfalfa age versus yield relationship. Review of the output from the price forecasting model indicates that prices fluctuate from $20 to $142 per ton for alfalfa, with a long term average of $60 to $65 per ton. The long term averages are $10 to $15 less than the $75 per ton used in the upper Missouri Water Reservations. As discussed later, a feasibility probability cutoff of greater than 50 percent will more than offset this difference (e.g., several years of higher than average prices for alfalfa). Experience indicates that most development will probably occur during the good years and not all farmers will weather poor years. Small grains (barley) range from $1.00 to $6.40 per bushel with a long term average of $1.95 per bushel. This value is less than the upper Missouri River CD Application values of $4.00 per bu. for spring wheat and $2.75 per bu. for malt barley. Malt barley is a specialty crop, not common like barley or oats. Prices were developed using the upper 25 percent of historical prices from ag statistics data. For this reason, a critic could argue that the upper Missouri River prices are high when considering a typical farmer. As with alfalfa, the lower price used for small grains will be offset with a cutoff greater than 50 percent (e.g., 90 percent was considered in conversations with DNRC staff). This consultant concurs with price forecasting model approach as it more accurately portrays the risks of the "real world" market. However, we believe that the nature of water reservations are such that the feasibility cutoff should be liberal with the "probability of success" approach.

The yield of alfalfa was based on two considerations. First, a good relationship has been found between consumptive use and yield. This consideration allows an adjustment for different climatic conditions throughout the basin. A spreadsheet was developed using data from four controlled plot studies in this region. An equation was developed as follows:

Yield (tons/acre) = 0.63 + (0.19*ET in inches)

The results from this equation were multiplied by 0.90 to allow for less than ideal conditions in actual fields versus controlled research plots. This equation provides peak yields ranging from 4.2 tons/acre in the Cut Bank area to 5.4 tons/acre in the Great Falls/Fort Benton area. These values are reasonable because of the high management and inputs assumed in the enterprise studies. Yields were varied with time considering minimal yields after establishment, slowly increasing to the 4th year and decreasing as the stand ages to the 7th year. The distribution was based on a report by Stauber (MSU). Review of these values indicates a very low yield in the first year after establishment. This degree of reduction, particularly in the first year after establishment, is questioned but we have no data to argue otherwise. We feel that more than one study is needed to support the yield vs. stand relationships. DNRC staff assumes that yields for small grains (typically irrigated barley) will be a constant 70 bushels per acre. This is a reasonable number, based on our review of ag statistics and conversations with farmers in the area.

Two other spreadsheets were used to develop a matrix of feasibility probability (expressed as percent chance) when compared against annual

irrigation cost in the Irrigation Design Analysis spreadsheet. The first spreadsheet is a Machinery Use spreadsheet which calculates the costs of owning and operating equipment. Review of this model was restricted to examining input parameters; equations and structure were not checked. We note that used equipment is allowed and machinery costs are reduced from comparable MSU enterprise studies. Most farmers, as prudent business persons, purchase some used equipment to reduce capital costs. We would concur with the use of used equipment. The acreage of small grain does not justify ownership of a combine. Custom combining is probably more prevalent. We note that the fuel use equation is different than the equation used in the Irrigation Design Analysis spreadsheet. The DNRC staff may want to consider using a consistent equation. Fixed and variable costs seem to be within the ranges that are expected.

The second spreadsheet is a Cost Enterprise Budget analysis merging the machinery costs with other cash and non cash costs associated with a particular enterprise. A cursory review of the farm budgets indicate reasonable input values for purchased items on the cost side of the equation. Costs of production are shown to vary with alfalfa yields; a task made simpler with spreadsheet analysis. No return to the investment in the farm (opportunity costs or return to equity) is shown. Return to labor is shown as $5.00 per hour and zero return to management is shown. As discussed in the next paragraph, this consultant questions the assumption of no returns to equity and management. Gross revenue from alfalfa falls in the range of $240 to $300 per acre. Of this revenue, $90 to $110 per acre is allocated to

fixed and variable costs. The balance is assumed to be available for irrigation development. Cut Bank, which has a short growing season, shows allowable annual expenditures for irrigation ranging from $67 (100 percent chance of feasibility) to $156 per acre for (0 percent chance of feasibility). Similar values range from $96 to $200 per acre for the Great Falls/Fort Benton area with better climatic conditions. These values are higher than expected for this area.

Our analysis shows that most of the enterprise costs consist of direct cash expenditures for fuel, seed, parts, machinery payments, etc. This leaves little for the farmer and his family to live on. Return to labor is about $6,400 per year ($1,000 for irrigation, $4,400 for machinery operation and $1,000 for the cow-calf enterprise). The USBR considers $15,000 to be a reasonable allowance for a farmer's year long efforts in the fields. For this reason, we would argue that some return to management and equity should be factored into the analysis, bringing the total return to labor, equity and management to $15,000. This would reduce the amount available for irrigation development by $35 to $40 per acre. This change could be offset by assuming additional risk with a higher feasibility percentage cutoff, such that the same number of projects remained feasible. This decision may be made by the Board at the time of approval.

QUALITY CONTROL RECOMMENDATIONS

A high priority quality control measure would be review of each project by an experienced staff member who has not worked on that particular project. Quality control can also be accomplished by looking at values throughout the spreadsheets and comparing them to expected values. For example, friction loss, expressed in feet/1,000 feet, will fall into a relatively narrow range of values for similar sizes of pipe. The hours of pumping for most irrigation systems should fall into the 1,250 to 1,500 hours band. Many other parameters can be established for reviewers and unusual values can be flagged for checking. Completion of the checklist in each file is a good quality control measure.

This review can also assist in quality control. It is likely that the items flagged in the review of the five individual projects will occur in other projects as well. These specific items can be searched out and corrected. It is quite likely that other minor errors will be noticed in later reviews.

The individual landowners could provide another source of input when the project is presented to them. This review should be solicted if practical. Time and budget constraints may not allow this approach.

Error trapping can be further developed within the programs but this will require considerable effort to complete. The mathematics should

be clean with spreadsheet calculations but errors in sum ranges, etc. can creep in. As the concepts mature, additional error trapping can be built in.

Input values are always subject to engineering judgement and can be argued within ranges. The use of published values from the SCS Irrigation Guide and Textbooks will add credibility to the input values.

Perhaps the best quality control measure is encouragement of a continuing effort for thorough and complete input from all of the disciplines involved. This comes naturally to most professionals but the effort always requires encouragement.

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APPENDIX B: Operator Interest Survey Information

Sample Cover Letter for
First Questionnaire

Blaine County Conservation District
Box 189 - Chinook, MT 59523 - Phone (406) 357-2310

Dear Landowner:

The Blaine County Conservation District is interested in obtaining a water reservation in the Missouri River Basin. As a public entity, the District is qualified to apply to the Board of Natural Resources and Conservation for the right to reserve water for existing and future beneficial uses. The water reservation proceeding is an opportunity to reserve water for future agricultural development within our district, and is a means of protecting Montana's water from claims by downstream states. Once granted, the District's water reservation will have a priority date of July 1, 1985.

As an agricultural operator in the county, you can help us prepare our water reservation application and benefit from this early priority date. If you know of a reliable irrigation water source not covered by a private water right claim or permit and have land suitable for irrigation, your project can become part of the District's application for reserved water. The first step is to complete the enclosed questionnaire and mail it in the return envelope as soon as possible.

Because of water shortages and the Milk River water rights closure, the water reservation application for the Blaine County Conservation District will be limited to projects using tributary water or projects using off-stream storage facilities for Milk River water.

If you have a potential irrigation project, you will receive a second questionnaire with maps and aerial photos on which to locate the water source and irrigable lands. The Department of Natural Resources and Conservation (DNRC) is helping us prepare our application. Any questions you may have about the water reservation process can be answered by calling our office at 357-2310, or the DNRC at 444-6637.

We stress the importance of the water reservation process in planning for future development and we ask your help in protecting Montana's Missouri Basin water.

Sincerely,

John D. Overcast Chairman
Blaine County Conservation District

Water Reservation
Fact Sheet Sent With
Questionnaires

WATER RESERVATION FACT SHEET

WHAT IS A WATER RESERVATION?

A reservation is a water right that allows the holder to claim water long before it is to be used. An early priority date is established even though the water might not be used for several decades. This gives the water user time to plan and finance the water use. Water can be reserved for existing or future beneficial uses, or to maintain the flow, level, or quality of water.

WHO CAN APPLY TO RESERVE WATER?

By law, only public entities (such as a state agency or conservation district) can apply for a water reservation. If a conservation district is granted a reservation, the individual farmers and ranchers may then apply to the district to use a portion of the reserved water.

WHO ADMINISTERS WATER RESERVATIONS?

Reservations are granted by the Board of Natural Resources and Conservation (Board). The Board usually sets a deadline by which the water has to be used. The Board then reviews the reservation at least once every 10 years to determine that the reservation holders are making progress toward putting the water to use. After each review, the Board may decide to extend the deadline, or revoke or modify the reservation if the objectives of the reservation are not being met. Reservations are legally authorized water rights and cannot be arbitrarily rescinded.

HOW DOES A WATER RESERVATION DIFFER FROM A WATER USE PERMIT?

1. Water use permits can be issued to public entities or directly to private individuals. Water reservations are granted only to public entities, that, in turn, let individuals put the water to use.

2. Generally, a permit requires that water is used within two or three years of issuance. Reserved water can be put to use many years or even decades in the future.

3. Preparing an application to reserve water requires more planning than is needed for a permit. During the reservation proceeding, the applicant and the state work together to produce a comprehensive water development and management plan.

4. The priority date of a permit is the date that the application is received by the Department of Natural Resources and Conservation. The priority date of water reservations granted during the current proceeding in the Missouri River Basin has been set by the legislature as July 1, 1985.

WHY RESERVE WATER IN THE MISSOURI RIVER BASIN?

There are two reasons that water reservations are appropriate in the Missouri River Basin. First, the additional time and comprehensive planning provided by the reservation process will encourage more efficient development and use of the Missouri's water resources. Reservations allow the conservation districts to protect the water from competing users while projects are carefully planned and developed.

Second, a basin-wide system of water reservations should provide a strong legal basis for protecting Montana's share of the Missouri's flow in any future interstate water right proceedings. Montana may soon face competition for Missouri River water from

downstream states. In response to this concern, the 1985 Montana Legislature directed the state to launch a reservation proceeding in the Missouri River Basin. Water users in the basin can reserve water now for use in the future when unappropriated water is more scarce.

ARE THERE ANY DISADVANTAGES TO A WATER RESERVATION?

To show that a reservation is needed, the applicant must prepare a detailed water-use plan that identifies all future water users and their estimated water needs. Such a plan is time consuming and expensive, but it ensures that water will be conserved and sensibly used to meet the future needs of the applicant. The legislature has made funding available to conservation districts to defray the costs.

WHAT IS THE PRIORITY DATE FOR THE MISSOURI RIVER BASIN RESERVATIONS?

The current reservation proceeding in the Missouri River Basin extends from July 1, 1985 to December 31, 1991. Any reservation granted in the basin during this time will have a priority date of July 1, 1985.

WILL THE WATER RESERVATION AFFECT MY EXISTING WATER RIGHTS?

No. Any request to reserve water is subject to pre-existing water rights, as adjudicated by the Montana water courts. If you have water rights with a priority date earlier than July 1, 1985, they cannot be adversely affected by any request to reserve water.

HOW CAN I PARTICIPATE IN THE RESERVATION PROCESS?

If you own or control land in the Missouri River Basin and plan to irrigate or store irrigation water in the future, or if you're thinking of diverting more water for land already under irrigation, you should contact your conservation district. The district will work with you to include your proposed project in the water reservation application. The district is relying on land-owners to come forward and declare their project proposals. Lands or water already covered by a water right claim or private water use permit are not eligible as projects in a water reservation application.

Please return the enclosed questionnaire to the conservation district, or visit the district office as soon as possible.

BLAINE COUNTY
CONSERVATION DISTRICT
WATER RESERVATION QUESTIONNAIRE

Name: _____

Address: _____
Box or Street City State Zip

Phone Number: _____

Do you know of a reliable water source (stream, spring, runoff, well) that could be developed for future uses?

Yes ____ No ____

Do you own or manage land that could be developed for future irrigation from this water source?

Yes ____ No ____

If you answered "Yes" to the above questions, please give the legal description for the land and the water source.

	Section(s)	Township	Range
WATER SOURCE:	_____	_____ North / South	_____ East / West
LAND:	_____	_____ North / South	_____ East / West

Sample of Cover Letter
Sent with Second Questionnaire

Dear Landowner:

You recently submitted a questionnaire to the DNRC regarding your interest in a water reservation application. We have enclosed a copy to refresh your memory. To fully evaluate the potential of your project, we need more information from you. Would you please fill out the enclosed detailed questionnaire and return it to us?

We will also need a map of your project area. We have enclosed a copy of an aerial photo of the general area you indicated an interest in developing an irrigation project in. Please outline on the map the exact area that you would need irrigation water for (please differentiate between "new" and "supplemental" areas), the proposed water source and point of diversion, and the boundary of the property you own and send the map back to us along with the questionnaire. Also, if you indicated an interest in a storage site, please indicate the exact location of the dam on the appropriate map.

DNRC personnel will be assisting the Conservation District in the preparation of a water reservation application. In that effort, it will be necessary to visit your proposed project site to confirm the irrigability of the soils, to look at the proposed water source, and to gather information necessary to

develop a preliminary design of an irrigation system. We have enclosed a permission form for you to sign giving DNRC field staff the right to enter your property for the purpose of conducting these necessary resource inventories. Please be assured that we will not enter your property for any reason other than the water reservation planning process. You may also indicate on the form if you wish to be present when we visit your site. To aid us in finding your proposed project site and to avoid areas you do not want us to travel through, would you please indicate on the enclosed map a route for us to follow in reaching the field and the water source.

Remember that the water reservation process has no effect on your existing water rights. Reserved water can, however, be used to supplement existing water rights if a new system is installed or an old system is rehabilitated.

Thank you for your cooperation in this important project.
Please return the requested information by XXXXXX XXXX.
If you have any questions, feel free to give us a call.

Sincerely,

District Chairman

(stick label here)

IF YOU DID NOT INDICATE THE NUMBER OF ACRES OR THE LEGAL LAND DESCRIPTION ON THE ORIGINAL QUESTIONNAIRE, PLEASE DO SO BELOW.

SUPPLEMENTAL: _____
NEW LAND: _____
LAND DESCRIPTION: SEC _____, T_____, R_____
_____, _____, _____
_____, _____, _____

IF YOU INDICATED A NEED FOR SUPPLEMENTAL WATER FOR LAND THAT YOU CURRENTLY IRRIGATE, WHEN DOES YOUR WATER SHORTAGE OCCUR?

JUNE _____, JULY _____, AUGUST _____, SEPTEMBER
HOW MANY YEARS OUT OF TEN DO YOU HAVE ENOUGH WATER?
COMMENTS: _____
_____

WHEN WOULD YOU DEVELOP THE ACREAGE YOU INDICATED AN INTEREST IN?

____1990 TO 1995
____1996 TO 2000
____2001 TO 2005
____2006 TO 2010
____2011 TO 2015
____2016 TO 2020
____2021 to 2025

WHAT CROPS WOULD YOU GROW? _____

WHAT CROPS DO YOU GROW NOW? _____

WHAT ARE YOUR CURRENT AVERAGE YIELDS? _____

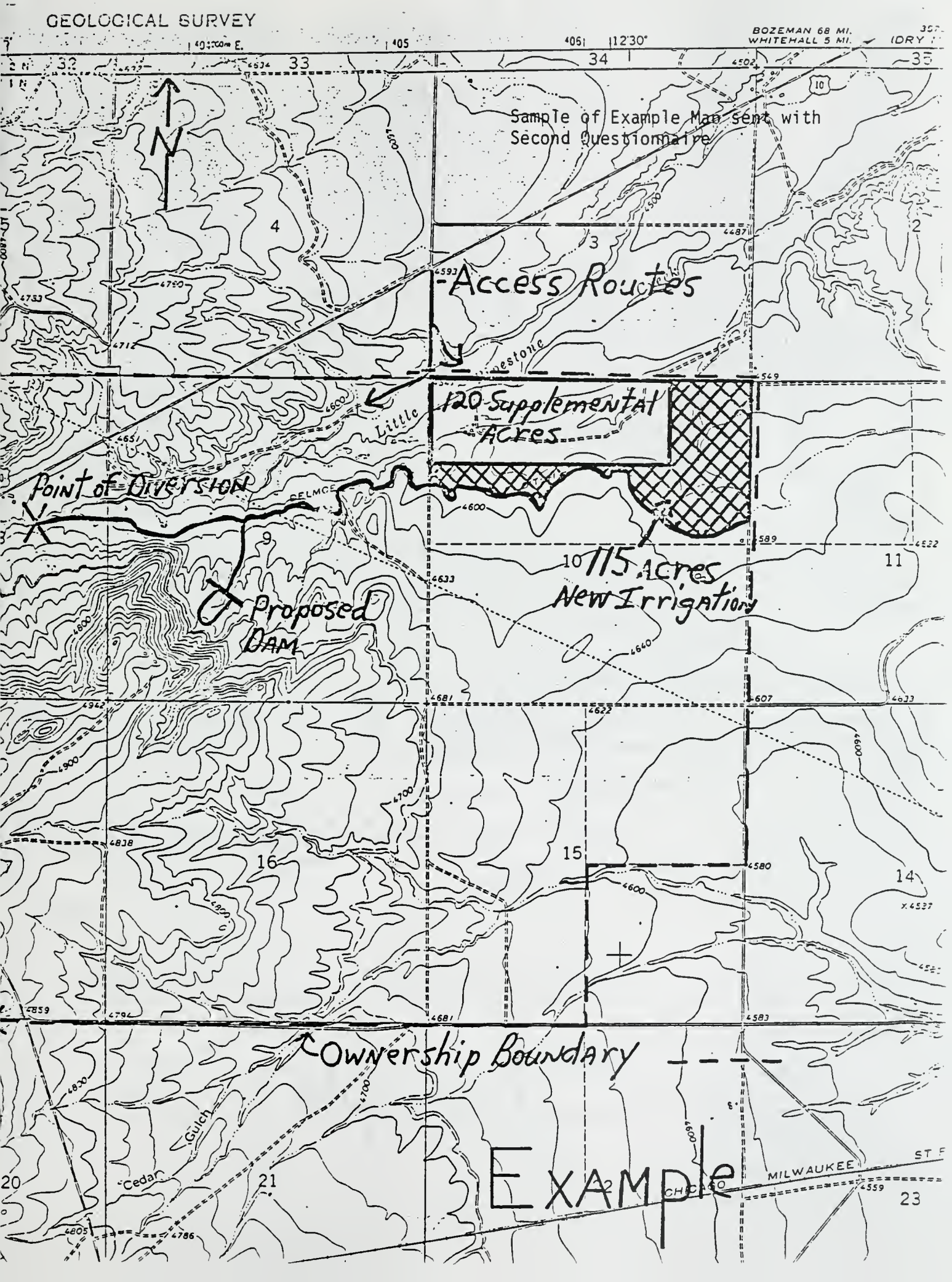
WHAT IRRIGATION SYSTEM WOULD YOU USE? _____

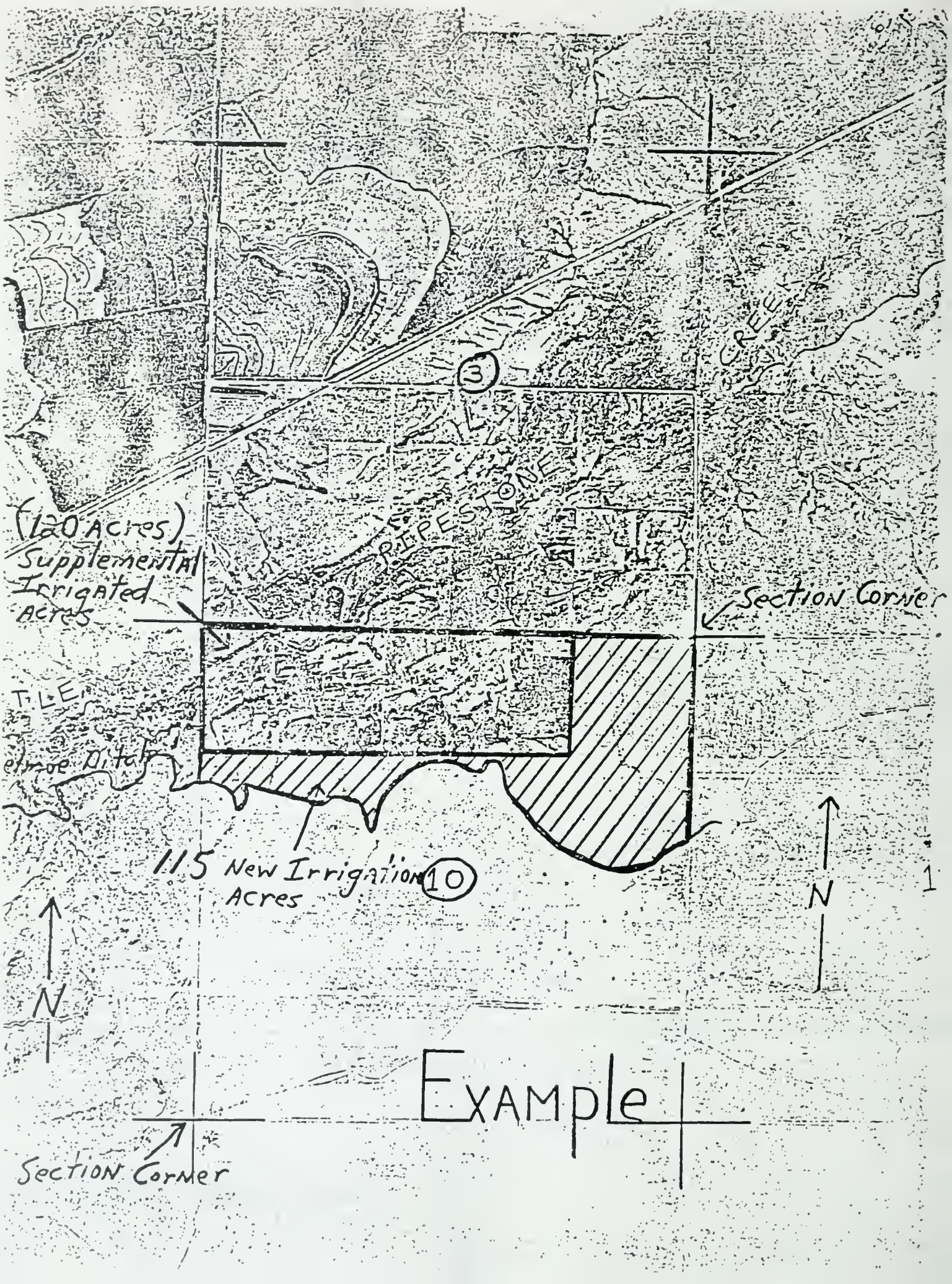
WHAT IRRIGATION SYSTEM AND PRACTICES DO YOU NOW EMPLOY? _____
_____
_____

WHAT WOULD THE WATER SOURCE BE? _____

NOTE: ON MAP(S) PROVIDED, COMPLETE THE FOLLOWING:
___ OUTLINE PROPOSED PROJECT AREAS
___ INDICATE WHICH IS NEW AND WHICH IS SUPPLEMENTAL
___ INSERT YOUR OWNERSHIP BOUNDARIES
___ INDICATE A ROUTE FOR FIELD CREW TO ACCESS THE AREA
___ INDICATE LOCATION OF PROPOSED STORAGE SITE (IF ANY)
___ INDICATE LOCATION OF WATER SOURCE AND POINT OF DIVERSION

COMMENTS: _____
_____
_____
_____
_____
_____


GEOLOGICAL SURVEY
BOZEMAN 68 MI.
WHITEHALL 5 MI.
IDRY
Sample of Example Map sent with
Second Questionnaire
Access Routes
120 Supplemental
Acres
Point of Diversion
Proposed
Dam
115 Acres
New Irrigation
Ownership Boundary
EXAMPLE
Little
Cedar
Gulch
MILWAUKEE
CHICAGO


3
PIPESTONE
(120 Acres)
Supplemental
Irrigated
Acres
Section Corner
T.L.E.
115 New Irrigation
Acres
10
N
N
Example
Section Corner

WATER RESERVATION LANDOWNER STATUS SHEET

Owner _____ CD _____

Address _____ Phone _____

_____

_____

Project Identification Number _____

Legal Location(s) _____

Status Item	Y,N or ✓	Date	Initials
1. Second survey completed (✓)	___	_____	_____
2. Project located on state and county maps (✓)	___	_____	_____
3. Irrigable soils on project site (Y,N)	___	_____	_____
4. Sufficient surface water (Y,N)	___	_____	_____
5. Sufficient ground water (Y,N)	___	_____	_____
6. Economically feasible (Y,N)	___	_____	_____
7. Field inspection conducted (Y,N)	___	_____	_____
8. Final reconnaissance-level design done (✓)	___	_____	_____
9. File reviewed and project design summary sheet completed (✓)	___	_____	_____

NOTES:

APPENDIX C: Synth Program and Methods Used to Estimate Crop Irrigation Requirements

```
C   MARKOV STREAMFLOW SIMULATION MODEL    (SYNTH)
C   January 18, 1989
C
C      This program can be used to estimate the monthly 80th percentile
C      streamflows for ungaged streams.  The Markov lag-one process
C      is used to synthesize 50 years of average annual streamflows,
C      then applies a monthly streamflow distribution to generate
C      50 years worth of monthly flows.  A frequency analysis of
C      the synthesized monthly flows is performed to determine the
C      estimated percentile flows.
C
C      The Markov and frequency analysis portions of this program
C      were lifted from Holnbeck's reservoir sizing model.
C
C
C
C
C ------------- MAIN PROGRAM DICTIONARY -------------------------
C
C        VARIABLE NAME      VARIABLE DEFINITION
C        _____________      ___________________________
C
C        ADATA(K,J)         AVERAGE MONTHLY INPUT DATA
C        ALPHA(K,I,J)       SUMMARY TABLES
C        ATHEAD(K,J)        TABLE HEADINGS
C        BETA(K)            CONSTANTS OR INITIALIZING TERMS
C        CNAME(K,L)         NAMES OF CONSTANTS AND INITIALIZING TERMS
C        I                  YEAR COUNTER
C        J                  MONTH COUNTER
C        TITLE(L)           STUDY TITLE AND DESCRIPTION
C
C
C ---------------------------------------------------------------
C
```

```
C Dimension and declaration statements
C
      COMMON TITLE(12),ATHEAD(10,12),ADATA(7,12),Q(50),
     &XX(60),ALPHA(60,60,13),CNAME(10,12),BETA(8),QQ(50),
     &QINFLO(50,12),RELESE(50,12),EOM(50,12),QOUT(50,12),TT(50),
     &P(60),EVAP(50,12),DATA(12),QCFS(60,13)
      REAL MU,LL(600),NETVAP(12)
      CHARACTER*15 FNAM1
      CHARACTER*15 FNAM2
C
C Number of tables
      II=1
C
C Number of monthly input arrays (ADATA arrays)
      JJ=4
C
C Number of years to be simulated
      KK=50
C
C Number of constants (Beta values)
      NN=2
C
      WRITE(*,314) ' What is the name of your input file?  '
      READ(*,316) FNAM1
      WRITE(*,314) ' What is the name of your output file?  '
      READ(*,316) FNAM2
  314 FORMAT(A)
  316 FORMAT(A15)
      OPEN(5,FILE=FNAM1)
      OPEN(6,FILE=FNAM2)
      OPEN(15,FILE='OPMID.WR1',STATUS='OLD')
      OPEN(16,FILE='OPMID.WR2',STATUS='OLD')
C
C
C
C
```

```
C  === READ STATEMENTS === (There are 6 sets)
C
C (1) Read Run Title
      READ(5,10)(TITLE(L),L=1,12)
C
C (2) Read Alpha Table Headings
      READ(5,10)((ATHEAD(K,L),L=1,12),K=1,II)
C
C (3) Read monthly arrays. These constants appear
C     in the input file, line by line, as follows:
C
C     1- Percent of Annual Runoff in each month - Wet Year
C     2- Percent of Annual Runoff in each month - Dry Year
C     3- Percent of Annual Runoff in each month - Avg Year
C     4- Conversion Factors - (ac-ft/month) to (cfs/month)
C
      READ(5,15)((ADATA(K,J),J=1,12),K=1,JJ)
   15 FORMAT(12F6.5)
C
      DO 21 J=1,12
      DATA(J)=ADATA(1,J)
   21 CONTINUE
C
C (4) Read in the headings for the constants
      READ(5,10)((CNAME(K,L),L=1,12),K=1,NN)
   10 FORMAT(12A4)
C
C (5) Read in the constants (Beta values). These appear in
C     the input file, line by line, as follows:
C
C     1- Average annual runoff, cfs (Qaa)
C     2- Standard deviation of Qaa
C
      DO 20 K=1,NN
   20 READ(5,25)BETA(K)
   25 FORMAT(F10.3)
C
C (6) Read in the 50 standard normal random sampling deviates
      READ(5,27)(TT(I),I=1,KK)
   27 FORMAT(F6.3)
C
C
C
```

```
C    If the input flow or std dev is less than 1.0, a conversion is made
C    from units of cfs to acre-feet.
C
C
      KCALC=0
      ICALC=0
      QMEAN=BETA(1)
      STD=BETA(2)
      IF (QMEAN.LT.1.001) KCALC=1
      IF (STD.LT.1.001) ICALC=1
      IF (KCALC.EQ.1.OR.ICALC.EQ.1) THEN
         QMEAN = QMEAN*723.795
         STD = STD*723.795
      ENDIF
C
C     STD=BETA(2)
C     ICALC=0
C     IF(STD.LT.1.01)ICALC=1
C     IF(ICALC.EQ.1)STD=STD*723.795
C
C  Additional input statistics required by the Markov model
C
      R1=-0.0631
      G=1.5571
C
C  Compute statisitcs required to perform log-normal
C  Markov streamflow synthesis
C
      SS=STD**2.0
      VARI=0.005
   30 VARI=VARI+0.0001
      Y=EXP(3.*VARI)
      YY=3.*EXP(VARI)
      YYY=(EXP(VARI)-1.)**1.5
      SKEW=(Y-YY+2.)/YYY
      IF(SKEW.LT.G)GO TO 30
      SQVAR=SQRT(VARI)
C
C
```

```
C Compute mean logarithm:

      MU=0.0
   33 MU=MU+0.001
      WY=(VARI+MU)*2.
      VAR=EXP(WY)-EXP(VARI+(2.*MU))
      IF(VAR.LT.SS)GO TO 33
C
C Compute Rho:
C
      PX=EXP(VARI)-1.0
      PY=(PX*R1)+1.0
      PZ=ALOG(PY)
      RHO=PZ/VARI
      AY=(VARI/2.)+MU
      AX=QMEAN-EXP(AY)
   38 ALL=0.0
      ZZ=(RHO)**2
      FACTOR=SQRT(1.-ZZ)*SQVAR
C
C
C Synthesize annual flows using a lag-one Markov model
C with a log-normal distribution:
C
      DO 47 I=1,KK
      IF(I.NE.1)GO TO 40
      IF(I.EQ.1)Q(I)=MU
      A=Q(I)-MU
      IF(I.EQ.1)GO TO 45
   40 A=HOLD-MU
   45 B=RHO*A
      C=MU+B
      D=TT(I)*FACTOR
      Q(I)=C+D
      HI=EXP(Q(I))
      QQ(I)=AX+HI
      HOLD=Q(I)
      IF(QQ(I).LE.0.0)QQ(I)=0.000001
      ALL=ALL+QQ(I)
   47 CONTINUE
C
C
      IF (KCALC.EQ.1.OR.ICALC.EQ.1) GO TO 448

C Convert flows from cfs to acre-feet
C (Do loop 444 used only when QMEAN is > or = 1.001 cfs)

      DO 444 I=1,50
      QQ(I) = QQ(I)*723.795
  444 CONTINUE
  448 CONTINUE
C
```

```
C  Disaggregate the synthetic mean annual flows into monthly
C  flows based on the input distribution:
C
      AVG=ALL/FLOAT(KK)
      WET=1.25*AVG
      DRY=0.75*AVG
C
      DO 51 I=1,KK
      DO 50 J=1,12
      IF(QQ(I).GT.WET)QINFLO(I,J)=QQ(I)*ADATA(1,J)
      IF(QQ(I).LT.DRY)QINFLO(I,J)=QQ(I)*ADATA(2,J)
      IF(QQ(I).GE.DRY.OR.QQ(I).LE.WET)QINFLO(I,J)=QQ(I)*ADATA(3,J)
   50 CONTINUE
   51 CONTINUE
C
      KCOUNT=0
      ICASE=0
  511 CONTINUE
C
C
C Zero out alpha arrays
      DO 74 K=1,KK
      DO 74 I=1,60
      DO 74 J=1,13
   74 ALPHA(K,I,J)=0.0
C
C Compute statistics and print results
      DO 76 I=1,KK
      DO 75 N=1,12
      ALPHA(1,I,N)=QINFLO(I,N)
   75 CONTINUE
   76 CONTINUE
C
C  Sum annual data in tables
      DO 80 K=1,II
      DO 80 J=1,12
      DO 80 I=1,KK
   80 ALPHA(K,I,13)=ALPHA(K,I,13)+ALPHA(K,I,J)
C
```

```
C  Compute means and frequency statistics for each month:
C
C   First, the means:
C
      DO 84 K=1,II
      DO 83 J=1,13
      DO 82 I=1,KK
      ALPHA(K,51,J)=ALPHA(K,51,J)+ALPHA(K,I,J)
   82 CONTINUE
   83 CONTINUE
   84 CONTINUE
      DO 86 K=1,II
      DO 85 J=1,13
      ALPHA(K,51,J)=ALPHA(K,51,J)/FLOAT(KK)
   85 CONTINUE
   86 CONTINUE
C
C
C  Next, the exceedance frequencies:
C
      DO 95 K=1,II
      DO 94 J=1,13
      DO 90 I=2,KK+1
      XX(I)=ALPHA(K,I,J)
   90 CONTINUE
   92 FL=0
      DO 93 I=2,KK
      IF(XX(I).LE.XX(I+1)) GO TO 93
      T=XX(I)
      XX(I)=XX(I+1)
      XX(I+1)=T
      FL=1
   93 CONTINUE
      IF(FL.NE.0)GO TO 92
      MODE=(KK/2)+3
      ALPHA(K,52,J)=XX(MODE)
      MODE=(KK*0.2)+3
      ALPHA(K,53,J)=XX(MODE)
      MODE=(KK*0.4)+3
      ALPHA(K,54,J)=XX(MODE)
      MODE=(KK*0.5)+3
      ALPHA(K,55,J)=XX(MODE)
      MODE=(KK*0.8)+3
      ALPHA(K,56,J)=XX(MODE)
      ALPHA(K,57,J)=XX(KK+1)
      ALPHA(K,58,J)=XX(2)
   94 CONTINUE
   95 CONTINUE
      SUMTRY=0.0
      SUMEND=0.0
      DO 452 J=1,12
      SUMTRY=SUMTRY+DATA(J)
      SUMEND=SUMEND+ADATA(1,J)
  452 CONTINUE
```

```
C Write Heading for output:
C
      WRITE(6,966)
  966 FORMAT(//,53X,42HMARKOV MODEL SYNTHETIC MONTHLY STREAMFLOWS)
C
      WRITE(6,967)
  967 FORMAT(52X,44H============================================,//)
C
      WRITE(6,968)
 968  FORMAT(62X,24H(Flows are in acre-feet),//)
C
C
C   Write Summary Tables:
C
      DO 115 K=1,II
C
      WRITE(6,101)(TITLE(L),L=1,12)
      WRITE(6,101)(ATHEAD(K,L),L=1,12)
  101 FORMAT(45X,12A4)
C
      WRITE(6,102)
  102 FORMAT(//,26X,3HOCT,5X,3HNOV,5X,3HDEC,5X,3HJAN,5X,3HFEB,5X,3HMAR,
     &4X,5HAPRIL,5X,3HMAY,4X,4HJUNE,4X,4HJULY,5X,3HAUG,4X,4HSEPT,3X,
     &3HTOT)
C
C     DO 105 I=1,KK
C     IYEAR=0+I
C
C     WRITE(6,104)IYEAR,(ALPHA(K,I,J),J=1,13)
C 104 FORMAT(18X,I4,13F8.2)
C 105 CONTINUE
C
      WRITE(6,106)(ALPHA(K,51,J),J=1,13)
  106 FORMAT(/14X,7HAVERAGE,1X,13F8.2)

C     WRITE(6,107)(ALPHA(K,52,J),J=1,13)
C 107 FORMAT(14X,7HMEDIAN ,1X,13F8.2)

      WRITE(6,111)(ALPHA(K,56,J),J=1,13)
  111 FORMAT(7X,14H20 PERCENTILE ,1X,13F8.2)

      WRITE(6,110)(ALPHA(K,55,J),J=1,13)
  110 FORMAT(7X,14H50 PERCENTILE ,1X,13F8.2)

      WRITE(6,108)(ALPHA(K,53,J),J=1,13)
  108 FORMAT(7X,14H80 PERCENTILE ,1X,13F8.2)

  115 CONTINUE
```

```
C Compute cfs from af/month

      DO 200 I=51,56
      DO 200 J=1,13
         IF (J.EQ.5) THEN
              QCFS(I,J) = ALPHA(1,I,J) / 55.5
         ELSE IF (J.EQ.13) THEN
              QCFS(I,J) = ALPHA(1,I,J) / 724.0
         ELSE IF (J.EQ.2 .OR. J.EQ.7 .OR. J.EQ.9 .OR. J.EQ.12) THEN
              QCFS(I,J) = ALPHA(1,I,J) / 59.5
         ELSE
              QCFS(I,J) = ALPHA(1,I,J) / 61.5
         ENDIF
 200  CONTINUE


      WRITE(6,202)
 202  FORMAT(//62X,24H(Flows below are in cfs),//)

      WRITE(6,204)
 204  FORMAT(//,26X,3HOCT,5X,3HNOV,5X,3HDEC,5X,3HJAN,5X,3HFEB,5X,3HMAR,
     &4X,5HAPRIL,5X,3HMAY,4X,4HJUNE,4X,4HJULY,5X,3HAUG,4X,4HSEPT,3X,
     &3HTOT)

      WRITE(6,206)(QCFS(51,J),J=1,13)
 206  FORMAT(14X,7HAVERAGE,1X,13F8.2)

      WRITE(6,211)(QCFS(56,J),J=1,13)
 211  FORMAT(7X,14H20 PERCENTILE ,1X,13F8.2)

      WRITE(6,120)(QCFS(55,J),J=1,13)
 120  FORMAT(7X,14H50 PERCENTILE ,1X,13F8.2)

      WRITE(6,208)(QCFS(53,J),J=1,13)
 208  FORMAT(7X,14H80 PERCENTILE ,1X,13F8.2)


      STOP
      END
```

Sample input file for the SYNTH program

```
CD-### PROJECT NAME (ref gage = #995)
Estimated Monthly Mean and Pecentile Streamflows (cfs)
040  .040  .030  .020  .030  .050  .10   .25   .30   .10   .04   .03
040  .040  .030  .020  .030  .050  .10   .25   .30   .10   .04   .03
040  .040  .030  .020  .030  .050  .10   .25   .30   .10   .04   .03
61.48  59.5 61.48 61.48 55.52 61.48  59.5 61.48  59.5 61.48 61.48  59.5
1-Average Annual Runoff, Qaa (cfs)
2-Standard Deviation of Qaa
  5.25
  2.12
 -0.523
  0.611
 -0.359
 -0.393
  0.084
 -0.931
 -0.027
  0.798
  1.672
 -1.077
 -1.536
 -0.454
  0.071
 -2.129
  1.525
  0.261
  2.319
  0.972
  0.767
 -2.849
 -0.121
  0.968
 -1.943
  0.581
 -0.711
 -0.060
 -0.482
 -0.746
 -0.747
  1.254
 -0.542
 -0.807
  0.168
  0.839
 -0.756
 -0.453
 -1.912
  0.766
 -0.890
  0.205
  0.131
 -0.859
```

```
-1.096
-0.785
 0.310
 1.314
-0.231
 0.029
 1.819
-1.602
```

Sample output from the SYNTH program

MARKOV MODEL SYNTHETIC MONTHLY STREAMFLOWS

(Flows are in acre-feet)

CD-### PROJECT NAME (ref gage = #995)
Estimated Monthly Mean and Pecentile Streamflow

	OCT	NOV	DEC	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	TOT
AVERAGE	145.42	145.42	109.07	72.71	109.07	181.78	363.56	908.90	1090.68	363.56	145.42	109.07	3744.67
20 PERCENTILE	191.02	191.02	143.27	95.51	143.27	238.78	477.55	1193.88	1432.66	477.55	191.02	143.27	4918.80
50 PERCENTILE	141.81	141.81	106.35	70.90	106.35	177.26	354.51	886.29	1063.54	354.51	141.81	106.35	3651.50
80 PERCENTILE	103.99	103.99	77.99	51.99	77.99	129.99	259.97	649.93	779.91	259.97	103.99	77.99	2677.70

(Flows below are in cfs)

	OCT	NOV	DEC	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	TOT
AVERAGE	2.36	2.44	1.77	1.18	1.97	2.96	6.11	14.78	18.33	5.91	2.36	1.83	5.17
20 PERCENTILE	3.11	3.21	2.33	1.55	2.58	3.88	8.03	19.41	24.08	7.77	3.11	2.41	6.79
50 PERCENTILE	2.31	2.38	1.73	1.15	1.92	2.88	5.96	14.41	17.87	5.76	2.31	1.79	5.04
80 PERCENTILE	1.69	1.75	1.27	0.85	1.41	2.11	4.37	10.57	13.11	4.23	1.69	1.31	3.70

Calculated Irrigation Water Demands for a Pipeline-to-Sprinkler Irrigation Project

PAGE 5-5 SUMMARY OF RESULTS (Alt R to print)

BASIN: #CH-21 Missouri River (Bailey)
NCIR = 1.74 ac-ft/ac

		MONTH	TOTAL DEPL'N (ac-ft)	TOTAL DEPL'N (cfs)
FULL SERVICE:				
Pipe/Sprinkler =	175 acres	OCT	-15	-0.24
Canal/Sprinkler =	0 acres	NOV	-11	-0.19
Pipe/Flood =	0 acres	DEC	-7	-0.12
Canal/Flood =	0 acres	JAN	-3	-0.05
		FEB	-1	-0.01
PARTIAL SERVICE:		MAR	0	0.00
Pipe/Sprinkler =	0 acres	APR	0	0.00
Canal/Sprinkler =	0 acres	MAY	40	0.65
Pipe/Flood =	0 acres	JUN	84	1.41
Canal/Flood =	0 acres	JUL	126	2.05
		AUG	93	1.51
WATER SPREADING:		SEP	19	0.32
Ditch/Flood =	0 acres			
		ANNUAL	325	0.44

MISSOURI RIVER BASIN WATER RESERVATIONS
Conservation District Applications
Evaluation of Surface Water Availability

NET CROP IRRIGATION REQUIREMENTS
by Weather Station
for an 80% chance dry year
(inches)

MONTH	AG AUGUSTA	CS CAS-CADE	CT CHES-TER	CH CHO-TEAU	CN CONRAD	CB CUT BANK	DN DUN-KIRK	FF FAIR-FIELD	FB FORT BENTON	GL GLASGOW	GF GREAT FALLS	HL HELENA	LW LEWIS-TOWN	ML MALTA	ST STAN-FORD	VL VALIER	WS WHITE SULPHUR SPRINGS
MAY	0.00	1.17	0.04	1.04	1.22	0.19	1.28	1.31	2.07	1.86	1.44	1.46	0.23	2.3	0.46	0.84	0.00
JUN	3.63	4.07	4.39	4.34	4.22	3.69	3.84	4.21	4.49	4.9	4.51	4.58	3.28	4.58	3.58	3.97	3.07
JUL	6.31	6.54	6.44	6.50	6.29	5.74	6.21	6.36	6.96	6.91	7.16	6.89	5.91	7.19	5.94	6.09	5.88
AUG	5.16	5.26	4.27	5.32	5.11	4.51	5.16	5.23	5.57	5.73	5.68	5.47	4.73	5.79	4.92	4.95	4.68
SEP	1.47	1.49	0.00	1.41	1.36	0.85	0.46	2.30	1.79	1.74	2.30	2.16	1.03	1.96	1.23	1.62	0.67
TOTAL	16.57	18.54	15.14	18.61	18.19	14.98	16.94	19.41	20.88	21.14	21.09	20.56	15.19	21.82	16.14	17.47	14.31
MAY	0.0%	6.3%	0.3%	5.6%	6.7%	1.3%	7.6%	6.7%	9.9%	8.8%	6.8%	7.1%	1.5%	10.5%	2.9%	4.8%	0.0%
JUN	21.9%	22.0%	29.0%	23.3%	23.2%	24.6%	22.7%	21.7%	21.5%	23.2%	21.4%	22.3%	21.6%	21.0%	22.2%	22.7%	21.5%
JUL	38.1%	35.3%	42.5%	34.9%	34.6%	38.3%	36.7%	32.8%	33.3%	32.7%	33.9%	33.5%	38.9%	33.0%	36.8%	34.9%	41.1%
AUG	31.1%	28.4%	28.2%	28.6%	28.1%	30.1%	30.5%	26.9%	26.7%	27.1%	26.9%	26.6%	31.1%	26.5%	30.5%	28.3%	32.7%
SEP	8.9%	8.0%	0.0%	7.6%	7.5%	5.7%	2.7%	11.8%	8.6%	8.2%	10.9%	10.5%	6.8%	9.0%	7.6%	9.3%	4.7%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(TR-21 runs made by Greiman 7/15/88)

Table D-1

GUIDELINES FOR INTERPRETATION OF WATER QUALITY FOR IRRIGATION[1]

Potential Irrigation Problem	*Units*	*Degree of Restriction on Use*		
		None	*Slight to Moderate*	*Severe*
Salinity[2]				
ECw	*mmho/cm*	*< 0.7*	*0.7 - 3.0*	*> 3.0*
or				
TDS	*mg/l*	*< 450*	*450 - 2000*	*> 2000*
Infiltration[3]				
SAR = 0 - 3 and ECw =		*> 0.7*	*0.7 - 0.2*	*< 0.2*
= 3 - 6 =		*> 1.2*	*1.2 - 0.3*	*< 0.3*
= 6 - 12 =		*> 1.9*	*1.9 - 0.5*	*< 0.5*
= 12 - 20 =		*> 2.9*	*2.9 - 1.3*	*< 1.3*
= 20 - 40 =		*> 5.0*	*5.0 - 2.9*	*< 2.9*
Specific Ion Toxicity				
Sodium (Na)				
surface irrigation	*SAR*	*< 3*	*3 - 9*	*> 9*
sprinkler irrigation	*me/l*	*< 3*	*> 3*	
Chloride (CL)				
surface irrigation	*me/l*	*< 4*	*4 - 10*	*> 10*
sprinkler irrigation	*me/l*	*< 3*	*> 3*	
Boron (B)	*mg/l*	*< 0.7*	*0.7 - 3.0*	*> 3.0*
Miscellaneous Effects				
Nitrogen (NO3 - N)	*mg/l*	*< 5*	*5 - 30*	*> 30*
Bicarbonate (HCO3)	*me/l*	*< 1.5*	*1.5 - 8.5*	*> 8.5*
pH		*Normal Range 6.5 - 8.4*		

1 Adapted from University of California Committee of Consultants, 1974.

2 ECw = electrical conductivity, a measure of water salinity in millimhos per centimetre (mmho/cm).
TDS = total dissolved solids in milligrams per litre (mg/l).

3 SAR = sodium adsorption ratio. At given SAR, infiltration rate increases as water salinity increases.

Source: FAO, 1985.

APPENDIX D: Water Quality Criteria

Table D-2

THRESHOLD CONCENTRATIONS
FOR FRESHWATER AQUATIC LIFE
AND IRRIGATION

Constituent	Units	Freshwater Aquatic Life (U.S. Environmental Protection Agency, 1976, 1980) [a,b]	Irrigation (National Academy of Sciences, 1972)
Arsenic	mg/l	440	100
Beryllium	mg/l	5.3	100
Boron	mg/l	--	750
Cadmium	mg/l	6.3	10
Chromium [c]	mg/l	21	100
Copper	mg/l	43	200
Fluoride	mg/l	--	1000
Iron	mg/l	--	5000
Lead	mg/l	400	5000
Manganese	mg/l	--	200
Mercury	mg/l	.0017	--
Nickel	mg/l	3100	200
Selenium	mg/l	250	20
Silver	mg/l	13	--
Zinc	mg/l	570	2000

a From USBR memorandum of August 21, 1985.
b Criterion for concentrations that should not be exceeded at any time; trace-metal concentrations are for hard water (hardness greater than 200 milligrams per liter as CaCO).
c Hexavalent chromium.

APPENDIX E: Forms Used During Field Investigations

WATER RESERVATION FIELD VISIT
RESOURCE INVENTORY

Field Staff: Complete this form, the Soils Information form, the Storage Site Info form (if applicable), and the Environmental Field Checklist for each potential water reservation project. Where appropriate, note information on project maps. Make an entry for each major category heading on all forms. If an item does not apply to the specific project or no problems are observed for a category enter "NA" or "None Observed" respectively.

Project No. _____ Date: _____

Owner: _____ Field Staff: _____

Legal Location: _____ _____

Soils: Soil scientist verify or modify soils information from office screening. Fill out Soils Information form.

Environmental Factors: All field staff contribute to filling out the Environmental Field Checklist.

Storage Site: Field staff complete form if necessary.

Topography: General topographic notes will be made on Soils Information form. For system design purposes, verify or note from topographic map the following items:

Approximate elevation of:

Water Source at POD: _____

High Point of Field: _____

Low Point of Field: _____

Benches in Field: _____

Project No. _____

Water Source: Gather as much information about the source of water supply as possible.

Source #1 NEW or SUPPLEMENTAL ? (Circle one)

Type (Circle): STREAM, SPRING, WELL, CANAL, DITCH

Name (if Named): _____

Trib. of (if appropriate): _____

POD: ___¼, ___¼, ___¼, SEC ____, TWP ____N/S, RGE ____E/W

Depth: _____

Width: _____

Note general clarity or amount of debris:

_____

Note suitability as, and/or constraints to, pump site location or gravity diversion: _____

_____

_____

_____

Note streambank stability: _____

_____

Source #2 NEW or SUPPLEMENTAL ? (Circle one)

Type (Circle): STREAM, SPRING, WELL, CANAL, DITCH

Name (if Named): _____

Trib. of (if appropriate): _____

POD: ___¼, ___¼, ___¼, SEC ____, TWP ____N/S, RGE ____E/W

Depth: _____

Width: _____

Note general clarity or amount of debris:

_____

Project No. _____

Note suitability as, and/or constraints to, pump site location or gravity diversion: _____

_____

_____

_____

Note streambank stability: _____

_____

Source #3 NEW or SUPPLEMENTAL ? (Circle one)

Type (Circle): STREAM, SPRING, WELL, CANAL, DITCH

Name (if Named): _____

Trib. of (if appropriate): _____

POD: ___¼, ___¼, ___¼, SEC ____, TWP ____N/S, RGE ____E/W

Depth: _____

Width: _____

Note general clarity or amount of debris:

_____

Note suitability as, and/or constraints to, pump site location or gravity diversion: _____

_____

_____

_____

Note streambank stability: _____

_____

Irrigation Wells in Area? YES NO (Circle one)

1. POD: ___¼, ___¼, ___¼, SEC ____, TWP ____N/S, RGE ____E/W
2. POD: ___¼, ___¼, ___¼, SEC ____, TWP ____N/S, RGE ____E/W
3. POD: ___¼, ___¼, ___¼, SEC ____, TWP ____N/S, RGE ____E/W

Project No. _____

Existing Physical Features and Obstructions: Make notes and indicate information on aerial photo or topographic ma as appropriate. Check each item off as considered. Indicate whether each item has been mapped or is "NA".

_____ Roads _____

_____ Power and telephone lines _____

_____ Buried utilities _____

_____ Fences _____

_____ Buildings _____

_____ Topographic constraints _____

_____

_____ Other _____

_____

_____

Existing Irrigation System: If request is for supplemental water or for an expansion of an existing system, evaluate the existing system. Enter notes or "NA" as appropriate.

Headgate (if accessible):

Type: _____

Size: _____

Vertical feet from creek bottom: _____

Repair: _____

Notes: _____

Canal, Ditch:

Depth: _____

Width: _____

Slope: _____

Repair: _____

Project No. _____

Pump: MFG: _____

Model: _____

Type: _____

GPM: _____

Feet: _____

Valving: _____

_____

_____

Other: _____

_____

_____

Existing Drainage System: Note anything observed regarding:

Condition of ditches: _____

_____

Evidence of underground drains: _____

_____

Problems created by lack of drainage: _____

_____

Other: _____

_____

Conveyance Route: Identify and note on map a proposed conveyance route for the pipeline or canal. Note any problems to be encountered along the proposed conveyance route. Note especially any soil or geologic constraints.

_____

_____

_____

_____

Project No. _____

Proposed Irrigation System: While in the field, complete a preliminary system layout on appropriate map(s). Note on apropriate maps the following:

Check: Notes:

_____ POD _____

_____ Pump _____

_____ Gravity _____

_____ Canal Route _____

_____ Pipeline Route _____

_____ Steel Pipeline Required _____

_____ Proposed System Layout

_____ If Flood, show field boundary

_____ If Sprinkler, show probable type

_____ If Other, specify _____

_____

_____ If electricity is required, note location of nearest 3-phase line _____

Additional Remarks:

Project No. _____

WATER RESERVATION
STORAGE SITE INFO

For projects involving potential storage sites, complete this form. Provide as much information as possible. Use a hand or Abney level to determine the height of the embankment. Use a tape or a wheel to determine the lenth of the embankment and the distance from the embankment upstream to the edge of the pool (pool length). Sketch embankment and pool on map and photo (if available).

Owner: _____

Date: _____

Field staff: _____

Exact Location: ___¼, ___¼, ___¼ Sec___, T___N/S, R___E/W
Locate on Quad and Photo Both

Ownership: Dam: _____

Inundated area: _____

Note general terrain: _____

_____

Proximity to supplemental water source (i.e., canal):_____

_____

Proximity to irrigable land: _____

_____

Amount and type of vegetation to be cleared: _____

_____

Accessibility of equipment: _____

_____

Embankment options:

Length: _____ Height: _____ Pool Length: _____

Length: _____ Height: _____ Pool Length: _____

Length: _____ Height: _____ Pool Length: _____

Project No. _____

Spillway location: _____

Comments: _____

_____

Basin shape and gradient: _____

_____

_____

Effects of inundation (pool): _____

_____

_____

Land use within inundated area (pool): _____

_____

_____

_____

_____

Potential hazard: Observe and note houses, county roads or highways, and campgrounds that would obviously be flooded and those that might be.

Obviously flooded:

Houses: _____

Roads: _____

Campgrounds: _____

Other: _____

Potential for flooding:

Houses: _____

Roads: _____

Campgrounds: _____

Other: _____

Project No. _____

Damsite Geologic Constraints:

____ 1. Porous Formations

____ a. Karst limestone (Lodgepole formation of Madison Group)

____ b. Volcanic breccia (from Craig downstream to mouth of canyon

____ c. Deep gravelly materials

____ 2. Fractured or unstable abutment materials

____ 3. Evidence of slope failure at site

____ a. Hummocky ground

____ b. Upslope fault scarps

____ c. Bulging soil at toe of slope

____ 4. Bedrock attitude at site

____ a. Beds dipping downslope

____ b. Channel bedrock dipping downstream

____ c. Channel bedrock dipping slightly upstream

____ d. Bedrock can't be observed

____ 5. Evidence of faulting at damsite

____ 6. Evidence of groundwater seepage

Reservoir Geologic Constraints:

____ 1. Dip slope geology - filling could initiate failure

____ 2. Oversteepened canyon walls

____ 3. Any evidence of slope failure

____ 4. Evidence of thick silty units within reservoir area

____ 5. Tipping trees along slopes

Project No. _____

WATER RESERVATION APPLICATION
SOILS INFORMATION

Owner: _____

Date: _____ Field No.: _____

Field Staff: _____ Stop No.: _____

General Project Description _____

_____

_____

_____

Soil Description

Series Name: _____ DNRC LAND CLASS: _____

Legal Location ¼ ¼ ¼ Sec.____ T____ R____

N. Veg. or Crop (Production Estimate): _____

_____

_____

Parent Material: _____

Bedrock: _____

Physiography: _____

Slope %:_____ Aspect:_____ Elevation: _____

Drainage:_____ Flooding or Subirrigation_____

_____

Salinity: _____ Erosion Potential:_____

_____

_____

Profile Characteristics

	Topsoil	Subsoil
Texture	Clay %_____	Clay %____
Coarse Fragment		
Effervescence		
Structure		
Peremeability		
Depth		

Additional Notes:

WATER RESERVATION APPLICATION
ENVIRONMENTAL FIELD CHECKLIST

PROJECT NO. _____

Owner: _____
Date: _____
Field Staff: _____

_____ Cultural Resources

1) Evidence of Prehistoric inclusion _____

_____

2) Evidence of Historic Activity _____

_____

3) Designated Recreation Sites _____

_____

_____ Biological Resources

1) Riparian Communities _____

_____

_____

2) Wetlands _____

_____

_____

3) Nesting Sites _____

_____

_____

4) Waterfowl Habitat _____

_____

_____

5) Observed Wildlife _____

_____

_____

APPENDIX C

JOINT TECHNICAL WORKING GROUP REPORT

WATER RIGHTS COMPACT

BETWEEN THE

STATE OF MONTANA

AND THE

DEPARTMENT OF THE INTERIOR, BUREAU OF LAND MANAGEMENT

1997

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November, 1998

JOINT TECHNICAL WORKING GROUP REPORT

OVERVIEW AND BACKGROUND 1

RIVER MODEL 2

DNRC WORKING GROUP 3

JOINT TECHNICAL WORKING GROUP 3

AVAILABLE WATER SUPPLY 3

CALCULATION OF DEPLETIONS 5

SURFACE WATER 6

- FISHERY, WILDLIFE, RECREATIONAL, AND WILDLIFE/WATERFOWL USES 6
- GEOTHERMAL AND POWER GENERATION USES 7
- DOMESTIC, MULTIPLE DOMESTIC, AND MUNICIPAL USES 7
- IRRIGATION 7
- STOCK USES 8
- COMMERCIAL, INDUSTRIAL, INSTITUTIONAL, MINING, AND OTHER PURPOSES 9
- TRANSBASIN DIVERSIONS 9

GROUNDWATER 9

STORED WATER 10

EFFECTS ON RIVER FLOWS 12

ADMINISTRATION 13

REFERENCES 14

JOINT TECHNICAL WORKING GROUP REPORT

OVERVIEW AND BACKGROUND

This report provides background and documentation of the technical methodologies and assumptions used in settling the reserved water rights claimed by the Bureau of Land Management (BLM) for the Upper Missouri National Wild and Scenic River (UMNW&SR). The technical work was completed by staff of the Montana Reserved Water Rights Compact Commission (RWRCC), Montana Department of Natural Resources and Conservation (DNRC), U.S. Bureau of Land Management (BLM) and U.S. Bureau of Reclamation (BOR).

In 1984, the BLM submitted to the RWRCC a technical report which quantified instream flow requirements of various elements for which they believed the UMNW&SR to be reserved (USBLM 1984). The report included flow requirements for side channels and riffles for fish spawning and rearing; safe passage of recreational floating vessels; protection of islands from predators of nesting geese; channel maintenance; and upstream migration of spawning paddlefish. These claims were later amended to include high flows for cottonwood regeneration and adjustments were made to the channel maintenance flows.

When negotiations resumed in 1992, the RWRCC and Federal team had opposing legal interpretations of the legislative act which reserved the UMNW&SR and could not agree on the primary purposes of the reservation. Consequently, the 1984 report was not accepted as a definitive analysis of flows required for the reservation, and the negotiators sought an alternative approach.

Instead of attempting to determine the natural attributes and corresponding water needs of the UMNW&SR, the negotiators agreed to determine a reasonable amount of water for additional State future use in the basin, leaving the remaining river flow as the BLM reserved right. Two technical teams were created to assemble information, analyze data, and recommend processes which would make implementation of the Compact practical.

The first team, the DNRC Working Group, was composed of representatives from bureaus within DNRC. This team was directed to determine a reasonable amount of future consumptive water use in the Missouri River Basin above Fred Robinson Bridge.

The second team, the Joint Technical Working Group (JTWG), was composed of technical personnel from state and federal agencies, including RWRCC, DNRC,

BLM and BOR. The duties of this team were to quantify the amount of water needed to supply future state water uses, create a methodology for calculating depletions from future uses of water, including surface, stored and ground water, and to analyze the effects of future depletions on existing streamflows within the UMNW&SR.

RIVER MODEL

The Upper Missouri HYDROSS (Hydrologic Operations Study) computer model was developed by the BOR to evaluate surface water supply in the Missouri River basin above Fort Peck Lake. The model was used by the JTWG to examine the effects of increased irrigated acreage in the basin on streamflows within the UMNW&SR.

The model includes simulations of flows on major tributaries and the Missouri River mainstem, and correlates irrigated acres to gaged streamflows for the period 1928 through 1987. Therefore, the model simulates the effects of existing or proposed development on historic naturalized streamflows.

HYDROSS can be used to perform theoretical future development scenarios in the basin, such as increased irrigated acreage or additional water storage. The model calculates average monthly flows for wet, average and dry water years, for any particular development scenario.

Since the model compares streamflows to irrigated acres, it does not take into account water rights which are legally valid, but were not in use during the period 1928 through 1987. Examples of such rights are the state water reservations that were granted by Final Order of the Board of Natural Resources on June 30, 1992. These water reservations for consumptive uses are not yet developed, but possess a 1985 priority date. Conversely, late-claim water rights were in use and their depletions were implicit in the model results.

The model reflects historic consumptive use through December 31, 1987. Instead of revising the model and extending it into the 1990s, depletions from water developments occurring after this date were calculated using the methods created by the JTWG and described in the compact.

A full description of the Upper Missouri model is included here as Attachment 1. The actual HYDROSS model and information used to develop the model are archived in the Montana State Library.

DNRC WORKING GROUP

A team of DNRC experts was assembled to calculate future consumptive water needs in the Upper Missouri River basin (MDNRC 1996). The report is included here as Attachment 2. Data assembled during the Montana Upper Missouri River Basin Water Reservations process were used to estimate economically feasible irrigable acreage in the basin (DNRC 1991). Based on soils, economics and other factors, the state water reservation studies identified approximately 100,000 acres (98,826 acres) which are currently not developed, but could be productive in the future.

Future municipal and industrial uses were also part of the state water reservations process. Several municipalities submitted reservation requests for additional water to supply increasing demands due to population and industrial growth. The reservations granted in the Board's Final Order were used by the Working Group to estimate future additional municipal and industrial needs to the year 2025 (MBNRC 1992). This amounted to 24,000 acre feet per year.

At this point, the technical groups had sound estimates of future additional agricultural development (100,000 acres), and future increased municipal and industrial demands (24,000 acre feet per year) in the Upper Missouri River Basin. The next tasks were to determine the depletions occurring from agricultural development, and insure that the amount of water set aside for future use was adequate.

JOINT TECHNICAL WORKING GROUP

The Joint Technical Working Group (JTWG) was composed of staff from the RWRCC, DNRC Water Management and Water Rights Bureaus, the BLM and the BOR. The JTWG was assembled to determine the amount of water needed to irrigate the projected 100,000 acres of additional acreage, recommend methods of calculating depletions from water use permits, determine the effects of future storage on streamflows, and recommend an accounting process for depletions occurring from groundwater withdrawals. The JTWG was also to recommend how any agreement would be administered without significant expense or additional work for DNRC.

AVAILABLE WATER SUPPLY

The amount of water set aside for future State uses was eventually called the Available Water Supply (AWS). The AWS is the allowable amount of additional

depletion in the upper basin, by month, beyond existing depletions (i.e., as of December 31, 1987). There is no minimum flow level at which the BLM may call users to stop using water, and the BLM cannot object to new permits within the volume amounts listed in the AWS.

The AWS was debated and altered several times to address concerns from both the State and BLM. The State argued that there should be enough water to satisfy irrigation demands of the 100,000 acres from direct flow, future storage (except on the mainstem of the Missouri River) and increased future municipal needs. The BLM was concerned that during dry years, the additional demands could deplete the river below historic low flows.

The JTWG began by calculating the difference between the 1984 BLM request (averaged by month) and the 1987 level of development median year (50% exceedence) monthly flows, as calculated by the HYDROSS model. This allowed very large depletion volumes during winter, which is a time of low water use. Therefore, the AWS was adjusted down for August through March by calculating the difference between the 1984 BLM request and the HYDROSS 75% exceedence flows.

The BLM then raised concerns that this version of the AWS would allow the river to drop below historic low flow levels during July and August of the 90% exceedence flow year. The BLM and other agencies felt that the river should not be intentionally depleted lower than 4000 cfs. Therefore, the AWS was lowered for July and August so that flows of 4000 cfs would remain instream during the 90% exceedence year. In exchange, the AWS was raised for September to allow depletion down to an instream flow of 4000 cfs during the 90% exceedence year.

The prospect of very low winter flows was a concern for the BLM. Low winter flows can severely impact resident fisheries because side channels, which are rearing areas for young fish, can dry out or freeze solid. Therefore, the AWS was reduced by 350 cfs for November through February.

Since the model outputs were based on the 1987 level of development, depletions from water uses occurring between 1988 and 1995 were also to be subtracted out of the AWS. Depletions from these uses were calculated using methods described in the compact. These depletions were then added back in to the AWS, to be removed after ratification of the compact. The monthly AWS figures were then rounded to the nearest 1000 acre feet.

At the final Negotiating Session between the State and BLM, the AWS numbers were changed somewhat. The parties had not reached agreement on how federal and Indian reserved water rights, as yet unquantified, would affect the AWS. BLM

was concerned with the impact to instream flow from development of unidentified, unquantified reserved water rights. To accommodate some level of future development outside of the State system, the AWS was lowered in April, May and June to numbers proposed by BLM based on their internal review. The AWS was also lowered in July and August to numbers suggested by the State to reflect water sufficient to meet future State needs instead of the historic low flow of 4000 cfs during the 90% exceedence year. Federal and tribal water rights will not be subtracted from the AWS. These were the last adjustments to the AWS.

The JTWG calculated an AWS that would satisfy post-1987 permits, provide water for about 100,000 acres of additional irrigated land and additional municipal needs, provide for the possibility of future non-mainstem storage (approximately 500,00 acre-feet), and not deplete the river below historic low flow levels.

The following table lists the AWS volumes from which future consumptive appropriations, beginning with those having priority dates of January 1, 1988, will be subtracted.

	Acre feet
January	104,000
February	121,000
March	124,000
April	185,000
May	219,000
June	62,000
July	82,000
August	66,000
September	40,000
October	35,000
November	57,000
December	98,000

CALCULATION OF DEPLETIONS

The JTWG produced a report recommending a methodology for calculating monthly depletions of various water uses (JTWG 1996). The report is included here as Attachment 3. The Compact specifies that in the future when the calculated depletions for a particular month equal the AWS for that month, the Missouri River basin above Fred Robinson Bridge (the downstream extent of the Missouri Wild and Scenic River) will close to additional consumptive appropriations for that month. Mont. Code Ann. § 85-20-501.

In developing depletion factors for different types of water use, the JTWG first eliminated non-consumptive water uses and other small uses, some of which are exempted by Montana statute. Such uses include instream flows for fisheries; domestic water use of 35 gallons per minute or less (surface or groundwater), up to 10 acre feet per year; permits for supplemental water; lawn and garden irrigation of five acres or less; and instream stock uses. Valid late claims are reflected in the HYDROSS model as existing development and federal and tribal water rights created under federal law are not subject to the State's regular permitting process and will not be subtracted from the AWS.

Consumptive water uses were placed into three categories based on the water source: surface water, groundwater and stored water. Depletion factors were developed for the various types of consumptive water uses, which were grouped by use codes currently employed by DNRC. The groups include ponds for fish, wildlife, stock and recreation; domestic and municipal uses; irrigation, including lawn and garden tracts greater than five acres; commercial, industrial, institutional and mining uses. Depletions are then calculated according to the source of the water and for the type of water use, and subtracted from the AWS.

SURFACE WATER

Monthly depletions for surface water uses are calculated and subtracted from the AWS in the month during which the use occurs. The depletion factors used in these calculations are listed in Appendix 1 of the Compact. Descriptions of the derivation of these factors for each category of water use subtracted from the AWS are presented below.

FISHERY, WILDLIFE, RECREATIONAL, AND WILDLIFE/WATERFOWL USES

FS Fisheries
FW Fish and Wildlife
RC Recreation
WW Wildlife/Waterfowl

Water use permit applications for fish, wildlife and recreation ponds have become quite common. Depletions from ponds occur primarily from evaporation. Evaporation factors used in the HYDROSS model were also used here to estimate these losses. The factors are based on monthly lake evaporation at Canyon Ferry Reservoir, which is located at approximately mid-basin.

The factors are listed by month, in feet per acre of pond surface area in Appendix 1 of the Compact. To calculate monthly evaporative loss in acre feet, the pond surface area (acres) is multiplied by the monthly evaporation factors.

GEOTHERMAL AND POWER GENERATION USES

GE Geothermal
PG Power Generation.

Applications for geothermal and power generation uses are rare and, because of the wide variety of possible consumptive water use needs, depletion factors for these types of water uses can not be reliably estimated. The JTWG recommended that depletions from water rights granted for these uses be determined on a case-by-case basis.

DOMESTIC, MULTIPLE DOMESTIC, AND MUNICIPAL USES

DM Domestic
MD Multiple Domestic
MC Municipal

Domestic, multi-family domestic, and municipal uses typically return a large percentage of their diverted amount in the same month that the use occurs. A reasonable estimate of depletion occurring from domestic or municipal uses is 40 to 50 percent of the diverted amount. Depletion factors for these uses were also taken from the HYDROSS model, and reflect an overall depletion of 45 percent of the annual volume of use.

The monthly factors are listed in Appendix 1 of the Compact. The factors vary by month because depletions associated with domestic water use are greater in summer months due to lawn watering and other outdoor uses of domestic water.

IRRIGATION

IR Irrigation
LG Lawn and Garden

It has been estimated that over 95 percent of all water consumed in Montana is used for agricultural purposes (USGS, 1991). The upper Missouri River basin covers approximately 41,000 square miles. Climate, soils and local water

supplies, which influence irrigation practices, vary greatly throughout the basin. This variability complicates estimates of water consumption by future irrigation. In order to keep the forecast of future agriculture reasonable, the JTWG operated under several assumptions while calculating depletions from the irrigation of additional acreage. The idea was to derive a set of variables that represent "average conditions" within the basin. Return flow characteristics, crop type and irrigation practices are examples of variables that were generalized to reflect future irrigation.

To estimate net water depletion from future irrigation, net irrigation requirements for alfalfa were first calculated using weather data at the Great Falls station. Since crop types fluctuate over time, the relatively water consumptive crop alfalfa was used in order to err on the high side of depletions, which would be in favor of river flows. Great Falls weather data was used because the station is located at approximately mid-basin.

Net depletion was then calculated from the net irrigation requirements by using a depletion efficiency of 80%. This figure assumes that there are some irrecoverable losses to deep groundwater and that return flows from sprinkler irrigation are low.

This method is not dependent on the type of irrigation used. It was assumed that future projects will be irrigated by sprinkler systems. The trend points toward sprinkler irrigation because it is far more efficient than other methods. That is, for a given acreage, the diversion amount is less for sprinklers than for other methods because the conveyance and application losses are lower.

These variables were written into a spreadsheet computer program which calculated the monthly depletion factors to be used in calculating depletions from future irrigation permits. The factors are listed in feet per irrigated acre in Appendix 1 of the Compact. When a permit is issued, the irrigated acres will be multiplied by the monthly depletion factor to calculate monthly depletions. Factors were derived only for months during which irrigation typically occurs: May through September.

STOCK USES

ST Stock

Depletions from stock ponds occur through evaporation. The depletion factors developed for pond evaporation for Fisheries, Wildlife, Recreational, and Wildlife/Waterfowl Uses will be applied in the same manner for stock ponds.

COMMERCIAL, INDUSTRIAL, INSTITUTIONAL, MINING, AND OTHER PURPOSES

CM Commercial
IN Industrial
IS Institutional
MN Mining
OP Other Purpose

This group encompasses a broad range of uses and corresponding depletion rates. These uses can range from almost non-consumptive to almost completely consumptive. Rather than attempt to define depletion factors for such a broad category, the JTWG recommended that depletions be calculated by assuming a 50 percent depletion to be spread in equal increments over the period of use of the permit until the permit development is completed and actual depletion factors can be calculated. The logic was that since these types of uses are not common, they account for very little impact to the surface water supply. The 50 percent depletion factor represents an average depletion rate for this group. That is, some uses will have greater depletions than 50 percent, some will have less. The impacts are spread equally over the period of use because of the same variability in uses.

A process was also created whereby the DNRC and BLM may discuss the monthly depletions for specific permits. DNRC will alter depletions to more accurately reflect actual depletions when sufficient information is available. To calculate depletions for each month then, the annual volume of a permit is multiplied by 50 percent, and divided by the number of months over which the water is used (e.g., divided by 12 for a year-round permit).

TRANSBASIN DIVERSIONS

Transbasin diversions remove water from one basin and transport water into another basin. It was assumed that any such diversion would be via pipeline, therefore the resulting depletion rate would be 100%, to be spread out over the period of use of the permit.

GROUNDWATER

Annual depletions from groundwater withdrawals are calculated using the methods for each type of water use described above. However, the monthly distribution of the annual depletion is different to account for the location of the diversions and

their effect on surface water flow. The effect on surface water varies greatly depending on the diversion location. For instance, a diversion located in a river floodplain may have an immediate depletion effect on surface flows. Depletions occurring from wells drawing from deeper aquifers may not show up for months or years, if ever.

Further complicating the calculation of groundwater withdrawals is the calculation of return flows. These calculations are based on basin geology and aquifer characteristics. The JTWG initially considered developing different monthly return flow coefficients for each sub-basin. However, the JTWG eventually agreed that in addition to severely complicating administration of the compact, the calculations would still be unreliable.

The JTWG weighed these factors and the uncertainty of the magnitude of future groundwater use, and recommended a uniform monthly depletion schedule, distributed evenly for each month of the year. In effect, the annual depletion will always be divided by 12 to calculate the monthly depletions for groundwater uses. For example, if the calculated annual depletion for an irrigation project is 1200 acre feet, the depletion for any month would be 100 acre feet (1200 acre feet divided by 12 months).

STORED WATER

For depletions due to future storage projects, the JTWG needed to develop a schedule that accounted for both reduction in flows due to the filling of reservoirs and depletions from the river system due to consumptive use of the stored water. The JTWG developed a depletion schedule based on average fill regimes of several smaller reservoirs in the basin. Included in the analysis were Middle Creek, Smith River, Swift, Martinsdale, Willow Creek and Ruby Reservoirs.

The rationale was that storage itself is not a depletion from the system (except for evaporative losses), but is a redistribution of river flows. Depletions come from the actual use of the water and are determined by first calculating the annual depletion based on the use for which the water is stored, then distributing it by month according to the reservoir depletion schedule. The depletion schedule is based on the average fill schedule of the five reservoirs, over the period 1961-

1990. The depletion schedule reflects the average percentage of storage that occurs by month during the storage season, November through June, as follows:

November	7%
December	8%
January	7%
February	7%
March	10%
April	21%
May	38%
June	2%

To determine the monthly depletion volumes, the annual depletion of the use for which the water is stored is multiplied by the above percentages. Additionally, evaporative losses from future storage projects must also be calculated by multiplying reservoir surface area by the monthly evaporation coefficients listed previously.

For example: a new reservoir is built to provide irrigation water. The reservoir has a surface area of 50 acres, and the annual depletion for the irrigation project is 5000 acre feet, calculated by using the irrigation factors listed earlier. The resulting monthly depletion distribution would be:

	Irrigation Depletion (acre feet)			**Evaporation Depletion (acre feet)**		**Total**
January	(7% X 5000) =	350	+	= 0	=	350
February	(7% X 5000) =	350	+	= 0	=	350
March	(10% X 5000) =	500	+	= 0	=	500
April	(21% X 5000) =	1050	+	(.08 X 50) = 4	=	1054
May	(38% X 5000) =	1900	+	(.17 X 50) = 8.5	=	1908.5
June	(2% X 5000) =	100	+	(.26 X 50) = 13	=	113
July	=	0	+	(.50 X 50) = 25	=	25
August	=	0	+	(.51 X 50) = 25.5	=	25.5
September	=	0	+	(.35 X 50) = 17.5	=	17.5
October	=	0	+	(.26 X 50) = 13	=	13
November	(7% X 5000) =	350	+	(.04 X 50) = 2	=	352
December	(8% X 5000) =	400	+	= 0	=	400
Totals		5000	+	106.5	=	**5106.5**

EFFECTS ON RIVER FLOWS

The compact allows for a considerable amount of additional depletion from the Missouri River system. However, given that some adjudication basins are permanently closed and most others are temporarily closed, full development of the AWS is doubtful. Water shortages on tributaries and large existing water rights on the mainstem Missouri River limit new development.

The following table illustrates full development, and therefore a worst-case scenario, with regard to Missouri River flows near Fred Robinson Bridge. Listed are the AWS in cubic feet per second (cfs), and the median monthly flows remaining instream after subtracting out the AWS during an average year (50% exceedence), a dry year (75% exceedence), and a very dry year (90% exceedence). For comparison, the median monthly flows (50% exceedence) for the years 1934 through 1995 and the historic monthly average low flow, both in cfs, are also listed.

	AWS (cfs)	Remaining Instream **50% Exceedence** (cfs)	Remaining Instream **75% Exceedence** (cfs)	Remaining Instream **90% Exceedence** (cfs)
January	1692	5899	5063	4150
February	2179	6202	5033	4380
March	2017	6899	6026	3991
April	3110	7390	5094	4061
May	3491	11021	7786	4344
June	943	15616	10943	7706
July	1202	9639	6009	4206
August	958	7088	5781	4336
September	609	6331	5273	4109
October	569	6186	5463	5041
November	958	6514	5570	4958
December	1594	6039	5049	4374

	Median Monthly Flows (cfs)	Historic Monthly Low Flow (cfs)
January	6649	2805 (1937)
February	7075	674 (1934)
March	8662	4884 (1937)
April	9759	4338 (1961)
May	14750	4860 (1992)
June	19930	4939 (1977)
July	10850	3956 (1940)
August	6617	2075 (1934)
September	6239	2501 (1934)
October	6593	3270 (1935)
November	6833	3581 (1938)
December	6700	3121 (1937)

Theoretically, even upon full development of the AWS, the river should not fall below historic minimum average monthly flows as a result of the additional depletions.

ADMINISTRATION

The DNRC Water Rights Bureau is currently encoding a computer accounting system to track permits, perform preliminary calculations of depletions and monitor the AWS. When the DNRC grants a permit, the type of use and other pertinent information will be entered into the system. Information currently required from applicants is adequate for administration of the compact. The depletions will be calculated and eventually finalized upon completion and verification of the permit. When depletions equal the AWS for any month, the basin above Fred Robinson Bridge will be closed to further appropriations during that month, except for those uses not subtracted from the AWS.

Each year, the DNRC will produce a report which summarizes permit activity, estimates depletions and tracks AWS levels. The compact authorizes an annual meeting between the DNRC and BLM to discuss the report, and any other issues pertaining to administration of the AWS and compact, such as calculation of depletions for undefined uses.

REFERENCES

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ATTACHMENT 1

UPPER MISSOURI RIVER WATER AVAILABILITY STUDY
HYDROLOGY MODEL DEVELOPMENT
10/15/1992

Introduction:

The Bureau of Reclamation (Reclamation), along with the Montana Department of Natural Resources and Conservation (MTDNRC) and the Montana Power Company (MPC), is working on a study to evaluate the water availability in the Missouri River Basin above Fort Peck Reservoir. The purpose is to determine if any water is available for future development within the basin. It is necessary to determine if any new irrigation or other water use will have an adverse impact on senior water right holders, land use, reservoir operations, water quality or others.

In order to accomplish this type of study, it is necessary to define the study requirements and develop all of the necessary data which reflect the actual operations within the boundaries of the study. Necessary parameters include: a representative period of record, selections of appropriate drainage basins and the delineations of those basins, county and node basins, irrigated acreage, crop distribution patterns, return flow distribution patterns, crop consumptive use, irrigation practice information, municipal and industrial uses, soils information, reservoir operations and historical streamflows among others.

The hydrologic data base will be assembled in the form of a computer model. This model will be used to determine what level of streamflows could be expected if a 1987 level of development occurred over the period of record. The 1987 level of development will serve as the baseline for conditions in the river system.

Period of Record

The period of record selected for this study was 1928 through 1987. This period was selected primarily to include the drought of the 1930's so if a similar period returned, it would be possible to evaluate the impacts of present development on that hydrologic period.

Selection of Drainage Basins

The MTDNRC, as part of their water reservation analysis, has selected drainage basins within the area of study. Many of the drainage basins are at the mouth of major rivers and tributaries, with some delineated into smaller subareas. In all, a total of 31 nodes or sub-basins were used by the MTDNRC for analysis. Reclamation has added 6 node basins to the original 31 as the result of a meeting with study cooperators. A map and list of node basins used in the current hydrology model is enclosed.

County Irrigated Acres

One of the most important parts in this analysis was the determination of the historical irrigated acreage for each node basin. Irrigated acres are reported by county rather than drainage basin, therefore it was necessary to separate the county data into node basin data. During 1978 through 1982, Reclamation, working with the Missouri Basin States Association on a Missouri River Hydrology Study, delineated drainage areas for many basins within the Missouri River. This study determined what portion of each county was situated within each drainage basin and the number of irrigated acres each county contributed to each drainage basin within the county boundaries. This data was evaluated for 1 year, 1978.

The primary source of data for irrigated acres was the U.S. Agricultural Census. This data is prepared every 4-5 years, and records were found for the period 1919 through 1987. Irrigated acreage data for years between census records was determined by straight line interpolation.

The State of Montana has prepared two water use studies which determine irrigated acres. One was done in 1975 and the other in 1980. Based upon discussion with the MTDNRC it was decided to incorporate the results of the 1975 evaluation into the current analysis. A comparison of the U.S. Ag Census data and the 1975 water use study revealed differences between the two sets of data. In order to define a uniform data set, it was decided to use the 1975 Montana data base and prorate the U.S. Ag Census data for the period 1929 through 1975 by using a ratio of the two data sets. This provided a set of county irrigated acres for the period 1929 through 1975 agreeable to both the MTDNRC and Reclamation.

In the 1987 update, Reclamation received 1987 preliminary county acres for the Upper Missouri Basin in Montana from the U.S. Ag Census. Using this data, Reclamation requested the U.S. Soil Conservation Service (SCS) to field check the data and provide concurrence of the 1987 data. In most cases, the data were different and at different ratios than the values used in the 1975 analysis. It was decided to maintain the 1929 through 1975 data base and modify the 1976 through 1987 period to reflect the new data received in the 1987 update. Once again, a ratio between the SCS data and the U.S. Ag Census data was determined. The U.S. Ag Census data was modified by taking the yearly acres multiplied by a value determined by a straight-line interpolation between the 1987 ratio and the 1975 ratio. This provided a data set compatible with the MTDNRC water use inventory and the 1987 SCS data.

As previously mentioned, the SCS provided a breakdown of what portion of the county's irrigated lands was located in the respective node basins. Although this data was prepared in 1978, it was the best information available. Thus, these percentages were used to determine how many acres were irrigated in each node basin. A computer program was written to disseminate and accumulate the county data into node basins within the study area.

Crop Distribution Patterns

The U.S. Soil Conservation Service was requested to provide information concerning the types of crop grown within each node basin. While disseminating the county irrigated acres to the respective node basins, they were also asked to provide the acreage of each crop within each node basin. Since a node basin may lie within several county boundaries, it was necessary to calculate a weighted crop distribution pattern. This was accomplished by

summing all similar crops acres from each county within the node basin and calculating a percentage of each crop to the total crop acreage in the node basin.

Crop Consumptive Use

A computer program, CONUSE3, was used to calculate crop consumptive use. This program has the capability to calculate crop consumptive use using Jensen-Haise or Blaney-Criddle methodology, diversion requirements, return flow requirements and depletion requirements on an annual basis for the period of record. This program was initially developed for use in the MBSA Hydrology Study and has been modified recently to reflect changes in technology and needed use.

In order to initiate the calculation of consumptive use, it is necessary to select a representative climatological station within each node basin. After the station was selected, average monthly temperature, total monthly precipitation, and solar radiation data was needed at each location for the period 1929 through 1987 as input to the CONUSE3 program. In several basins, a complete record was not available. In these cases, the monthly average for the particular climate zone was used to fill in the missing record. These stations were selected generally near the middle of the drainage basin to promote average conditions. More than one climatic stations were used for several of the larger node basins. The climatic station used for each node basin is enclosed.

In this analysis, the Jensen-Haise computer program for estimating crop consumptive use was used. The Jensen-Haise methodology requires the use of solar radiation data as an input requirement. Since solar radiation real time data is not readily available in the Upper Missouri Basin, an equation to calculate solar radiation using percent of possible sunshine data was used. National Weather Service first order stations collect monthly percent of possible sunshine data. It is possible to calculate the data using the latitude of the climatological station and the percent of possible sunshine data from a nearby recording station with reliable confidence.

With all of the input data collected, it was possible to calculate the crop consumptive use for each crop within the node basin as well as a weighted crop consumptive use.

Reclamation, in the late 1970's, added a subroutine to the Jensen-Haise program which allowed for the calculation of the crop irrigation requirement (CIR). This subroutine took into account several key factors in the development of the CIR. It analyzed monthly precipitation and, using Reclamation guidelines, calculated a monthly effective precipitation; it uses an available soil moisture holding capacity and average root depth of the crops; and it requires an irrigation when available soil moisture nears 50 percent depletion or at wilt/stress stage.

The program was written with a fixed available water content for the end of each month of the irrigation season. These end-of-month values are April - 100 percent, May - 95 percent, June - 90 percent, and July through October - 80 percent. This criteria limits the amount, either precipitation or irrigation, which the soil will hold during each irrigation month. This provides the crop with a sufficient supply of water to optimize production. There are instances, especially during April and May, when the effective precipitation, when added to

the available soil moisture value, exceeds the water holding capacity of the soil and runoff or deep percolation occurs. The program retains the remaining soil moisture present at the end of the irrigation season and uses it, plus the effective precipitation throughout the winter, to begin the next year's irrigation season. Generally, there is sufficient moisture throughout the winter to refill the profile to a full state, and irrigation requirements are not realized until later in the summer.

Conveyance and On-Farm Efficiencies

Conveyance and on-farm efficiency data has not been well documented in the Upper Missouri Basin area. Reclamation has made contact with various State natural resources agencies and in particular the SCS in hopes that reliable figures could be obtained. The SCS published a Water Conservation and Salvage Report which provides estimates of efficiencies and the SCS themselves cite this document as only an estimate.

Reclamation used the SCS Water Conservation and Salvage Report data provided in the MBSA Hydrology Study to determine appropriate conveyance and on-farm efficiencies. The following efficiencies were used for most node basins.

Furrow Gravity Surface System
Conveyance Efficiency - 50%
On-Farm Efficiency - 40%

Center Pivot Surface Sprinkler
Conveyance Efficiency - 50%
On-Farm Efficiency - 65%

Other Sprinkler Surface Sprinkler
Conveyance Efficiency - 50%
On-Farm Efficiency - 65%

Center Pivot Ground Sprinkler
Conveyance Efficiency - 95%
On-Farm Efficiency - 65%

Other Sprinkler Ground Sprinkler
Conveyance Efficiency - 95%
On-Farm Efficiency - 65%

A feature built into the CONUSE3 program allows for the automatic adjustment in efficiencies during a dry period. The program calculates the annual CIR and an average annual CIR throughout the period of record. The average annual CIR is then multiplied by 120 percent to arrive at an adjusted CIR value. The 120 percent is an input value and was determined through evaluation as an acceptable value. The adjusted CIR number is then compared to each year annual CIR value. If the annual CIR value is greater than the adjusted CIR value, then a dry year is projected and an adjustment in the efficiencies is made and the diversion requirements are recalculated. The rationale to perform this operation is

merited based upon the assumption that the irrigators will be more efficient during a dry period and the amount of water diverted would have to adjusted.

During the development of a natural flow data base, it became apparent that for some basins, the efficiencies used were not acceptable. Because the efficiencies were only estimates, Reclamation felt the error associated with the estimates was plus or minus 10 percent. Thus, the efficiency was increased up to 10 percent for several basins to achieve realistic natural flow values.

Return Flow Delay Patterns

The MTDNRC performed a somewhat detailed analysis of the return flow for each node basin by collecting data used to calculate Gloverian factors for use in Glover's method of predicting return flows. The MTDNRC used a systematic method to obtain the basic information and document the measurements and estimates used to make final estimates of a Gloverian factor for each node basin.

The following is a summary of MTDNRC's methodology:

* Base maps were prepared using land classification maps.

* The lands within each node basin were classified as either unfarmed highlands, sparsely drained lowlands or densely drained lowlands.

* The node basins were divided into subareas which were generally smaller than the tributary basins of similar geomorphic characteristics.

* Areas of each land category were measured with a planimeter, and lengths of tributaries suspected to act as drains were measured.
* Drain spacing was calculated by dividing each categorized area by the length of draining tributaries within or adjacent to the area.

* Estimates of transmissivity were made by using specific capacity information from State well logs.

* Storativity was assumed to be .22 for densely drained areas, .12 for tertiary upland deposits, and .17 for subareas in which both types of deposits were present, but were not densely drained.

* Gloverian factors were calculated for each land category in each subarea.

* Gloverian factors for each land category in each subarea were multiplied by the percent of irrigated land in the node basin to provide a weighted average value for each node basin.

The MTDNRC indicated that using a single value to reflect the return flow characteristics for extremely large areas in which basin data is scarce leaves room for many uncertainties. However, the final values are largely the result of the dominant values generated from intensely irrigated, densely drained floodplain areas of relatively large extent and having high

transmissivity values. Thus the overall area error is largely restricted to data obtained for these particular areas.

Reclamation used the return flow patterns developed by the MTDNRC in most cases. However, in some node basins, the Gloverian factor was modified so realistic natural flow values could be determined. Reclamation chose to modify these factors because of the subjectivity used in their determination.

The return flow delay patterns mentioned above are applied to that portion of agricultural losses, either from on-farm or conveyance system loss, which enter into the subsurface. Reclamation assumed 60 percent of any water lost and not non-beneficially, consumptively used returns to the stream during the same month it was diverted via surface water returns. Surface water returns originate from sources such as field runoff, agricultural drains, and canal wasteways. The remaining 40 percent of the loss is assumed to percolate into the ground and return to the stream via the subsurface. Reclamation assumed that 25% of the water which was lost did not return to the system and was non-beneficially consumptively used.

Municipal and Industrial Use

Municipal depletions were calculated for three large communities in the Upper Missouri River Basin: Great Falls, Bozeman, and Helena. Population figures were taken from U.S. Census Reports for the period 1930 through 1980. Population projections through 1987 were made available from the respective communities. Estimates of per capita day usage of water for each community were taken from MBSA reports and from an unpublished Reclamation document. Average annual withdrawals were calculated using the population figures and the per capita usage figures.

Several assumptions, regarding return flow and depletion rates, were taken from the MBSA study. They include: all the return flow were returned within the same month of diversion, and the depletion rate would be 45 percent of the diversion.

After the depletions were calculated on an annual basis, a monthly distribution was determined, again using information from the MBSA report. The values used are:

Jan - .03	May - .10	Sep - .11
Feb - .03	Jun - .13	Oct - .08
Mar - .06	Jul - .18	Nov - .03
Apr - .07	Aug - .15	Dec - .03

Calculation of Depletions

At any given node basin there may be a variety of depletions occurring from agricultural, municipal and/or industrial use. Depletions can be either positive or negative. For example, agricultural depletions are generally positive during the irrigation season. However, after the irrigation season, during the fall and winter, agricultural depletions are generally negative due to return flows coming back to the stream. A negative depletion means more water is entering the stream reach than is being removed.

A depletion is calculated by summing all of the diversions, agricultural, municipal or industrial, in a node basin during a given month and then subtracting any returns to the node basin during the same month. Returns to a node basin during a given month can originate during that month or any of the previous 11 months.

An agricultural diversion value is calculated by multiplying the acreage by the crop irrigation requirement then dividing by both the on-farm and conveyance system efficiencies. There is a possibility of 8 different types of agricultural diversion for each node basin depending upon the type of irrigation and whether a full or partial supply is delivered.

A municipal diversion is calculated by multiplying a population by the estimated water use per person per month. The depletion rate was assumed to be 45 percent of the diversion requirement.

Calculation of Naturalized Flows

The U.S. Geological Survey (GS) is recognized as the responsible Federal agency for obtaining field data and for manipulating certain data sets to meet specified needs. Because most of the sites where naturalized flows are required are GS streamflow gaging sites or at reservoir locations, and because the GS has developed long-term extended flow records for many sites in the basin, Reclamation requested the GS to develop the naturalized flow record. A naturalized flow set was required for each node basin for the entire period of record.

The human-caused flow depletions for each node basin were provided to the GS by Reclamation. Records of monthly changes in storage and surface area were furnished by Reclamation for all reservoirs where Reclamation maintains such records. All other reservoir data was obtained by the GS from appropriate Federal and State agencies.

At all node basins with reservoirs, the historical monthly flows were adjusted algebraically by adding the recorded changes in storage and the net differences in estimated monthly precipitation and evaporation. Monthly depletions were then algebraically added to the adjusted monthly flows to produce estimates of monthly natural flows. At all other gaged sites, the estimates of monthly natural flows were computed by algebraically adding the monthly human-caused depletions.

To obtain extended records of natural flow for the period of record at all sites, a record extension program was used. The program uses a mixed-station approach for extending monthly flow records in which any of several long-term base stations can be used to fill in missing months of data. The record extension program was used only after all historical flows had been adjusted to natural flows and was used only to extend natural flows.

For ungaged sites, natural flows were estimated from regression equations or the application of a drainage area adjustment to upstream or downstream flows.

A total of 15 reservoirs were considered in this analysis and are listed below:

Canyon Ferry	Swift
Clark Canyon	Ruby
Gibson	Madison
Tiber	Holter
Lower Two Medicine	Hauser
Hebgen	Black Eagle
Willow Creek	Lima
Willow Creek near Harrison	

Hydross Model and Canyon Ferry Operations Model

Reclamation's Hydrologic River Operations Study (HYDROSS) model was chosen as the model to use in this analysis. HYDROSS is a surface water supply model developed to assist in planning studies for evaluating existing and proposed demands on a river system. It is intended to operate over a period of record, simulating the effect of existing and proposed features on the historic naturalized flow.

HYDROSS is a system of computer programs for use in conducting monthly water supply studies and can be thought of as a hydrologic accounting model. HYDROSS is a very powerful water supply analysis tool because it allows the user the flexibility to conduct "what if" studies with ease.

Basic input to HYDROSS consists of three data files; flow data, table data and network data. Conceptually, the flow file contains the naturalized monthly flow data at river stations to be modeled. The table file is a means of introducing operational parameters to the model. The network file furnishes HYDROSS with a physical description of the study area; how stations connect, physical facilities and demand locations.

HYDROSS operates on the data in a strict sequential order in time (results from one month depend on the system state at the end of the previous month), space (results at one station depend upon what is happening upstream and/or downstream), and priority (earlier priority dates are allowed water before later priority dates).

HYDROSS offers a relatively strong reservoir operating procedure. However, HYDROSS does not allow streamflow forecasting in its reservoir operating routine. Because Canyon Ferry Reservoir serves as a re-regulation point in the basin, Reclamation felt Canyon Ferry Reservoir needed to be operated with the capability of using streamflow forecasts. The Canyon Ferry Reservoir Operations Model, used by Reclamation to assist in the actual operations of Canyon Ferry Reservoir, was linked to HYDROSS so HYDROSS could more realistically model Canyon Ferry Reservoir.

Output from HYDROSS is available in a variety of formats and can be easily customized to suit almost any need. A small sample of the types of output available from HYDROSS is enclosed.

ATTACHMENT 2

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION

MARC RACICOT, GOVERNOR

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MEMORANDUM

TO: BLM NEGOTIATING TEAM
RESERVED WATER RIGHTS COMPACT COMMISSION

FM: DNRC/RWRCC WORKING GROUP

RICH MOY RM
LAURENCE SIROKY LS
JACK STULTS JS
LARRY DOLAN LD
KIRK WAREN KW
STEVE SCHMITZ SS

BILL GREIMAN BG
DAVE AMMAN DA
CRAIG BACINO CB
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APPROVED: MARK SIMONICH, DIRECTOR Mark A. Simonich
GARY FRITZ, WATER RESOURCES ADMIN. Gary Fritz

DT: June 10, 1994

RE: Initial Report on Future Development in the Upper Missouri River Basin

The Compact Commission requested input from the Department of Natural Resources and Conservation (DNRC) on current negotiations with the Bureau of Land Management (BLM) regarding their reserved water right claims for the Wild & Scenic stretch of the Missouri River. A Working Group was formed with the DNRC to gather information and explore ideas on how to define the nature and scope of future development in the upper Missouri River Basin.

BLM's concerns have focused on impacts to flows from future consumptive use development and future storage. The Working Group looked at these issues as well as questions regarding administration.

The basic objective of the State is to provide management flexibility for future growth. BLM is open to subordinating their claimed right to future depletions, however, the level of future depletions must be supported by the State and impacts to flows analyzed.

All information contained in this report has supporting documentation available at the RWRCC office.

Consumptive Use Development

Larry Dolan has reviewed irrigable acreage for new development in the Missouri River basin. Fortunately, extensive review of potential irrigation development was recently done for the Missouri River reservation process. (Final Order, June 30, 1992.) The DNRC worked very closely with the area Conservation Districts in preparing applications for water reservations that included most of the potentially feasible irrigation projects in each District. Larry has summarized the information.

IRRIGABLE ACREAGE IN THE MISSOURI RIVER BASIN ABOVE THE FRED ROBINSON BRIDGE.

Granted by the Board in Upper Missouri River basin water reservation proceeding	33,865 acres
Applied for by the Conservation Districts during the upper Missouri basin water reservation proceeding	126,342 acres
Projects determined to be economically feasible in the EIS done for the upper Missouri basin proceeding	98,826 acres

(Memo dated May 12, 1994.)

Therefore, 98,826 acres applied for were economically feasible on their own merit (the direct benefits exceeded the direct costs). Of those acres, water reservations were granted for 33,865 acres to be developed by the year 2020. The remaining 64,961 acres were not granted reservations because total costs - with the indirect costs, including existing hydropower and recreation values - outweighed total benefits.

The acreage for the BOR's Virgelle project is not included in these figures. The Virgelle project calls for 53,600 acres of new and supplemental irrigation in the Milk River basin with a flow rate of 230 cfs. During the reservation process, the BOR stated that depletions from the Missouri River that conflicted with BLM's claims for the Wild & Scenic would be augmented by flows from Tiber Reservoir.

Bill Greiman worked with the Conservation Districts in putting together the original applications for water reservations in the Upper Missouri River basin. He stated that a thorough review of irrigable acreage was done at that time and that most of the potentially feasible projects of significant size were included in the applications.

The Working Group is currently studying future water use for municipal and industrial purposes. The Commerce Department will provide population projections. It is not anticipated that these uses will require significant amounts of water (consumed).

Currently, the Madison, Jefferson, and Teton drainages are permanently closed to new appropriations. The entire upper Missouri River above Morony Dam is temporarily closed to new appropriations until the adjudication process is completed. However, these closures do not prohibit the development of new storage facilities. Instream flow reservations may also be modified to allow for feasible new storage facilities if the resource values are maintained or enhanced by the storage facility.

Storage

Some initial model runs have been done to show the effects of additional storage on BLM's claimed reserved water right. The results indicate that new large storage projects may have some impacts but small storage projects would have no impact and cannot even be reliably modelled. BLM's concern with small storage appears to be how we define what "small" storage is and how cumulative effects would be measured.

Laurence Siroky stated that 12,500 acre/feet is the maximum size for the SCS's engineering standards under its P.L. 566 program for cost-sharing. This size limit is for active storage and for multiple-use projects. Design standards for larger reservoirs would fall under the BOR's or Corps' programs.

The Working Group has not yet analyzed how cumulative effects of small storage, since BLM has not specifically stated their concerns.

Administration

The Working Group has discussed several issues dealing with administration of BLM's reserved water right. However, until BLM has reviewed the impacts of future development on the Wild & Scenic stretch of the Missouri River and stated its position, it is premature to address these issues.

Other issues such as groundwater may arise during the negotiations. The Working Group will address those issues as necessary.

Conclusion

There is substantial support for the State to pursue negotiations for a volume of water to provide for 98,826 acres of potential irrigation development (mostly full service). These acres have undergone extensive economic analysis and are economically feasible to develop on their own merit. These acres also represent the majority of sizable potential irrigation projects in the upper Missouri River basin and the Conservation Districts have demonstrated their interest in developing them. Since irrigation is the most consumptive of potential new development, this use should be the benchmark for identifying a negotiated volume of water for future development. Other uses of water, such as

municipal or industrial, could be accommodated from the water identified by potential irrigation or a small volume could be added to provide for other purposes.

If the negotiations include discussions of storage, the use of federal engineering design standards to define "small" storage makes sense and would provide that most local potential storage projects would fall under the definition of "small."

ATTACHMENT 3

JOINT TECHNICAL WORKING GROUP:

MONTANA DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION/
RESERVED WATER RIGHTS COMPACT COMMISSION/
BUREAU OF LAND MANAGEMENT

1996

TECHNICAL ADDENDUM TO MONTANA AND FEDERAL NEGOTIATING TEAMS

INTRODUCTION

A working group was assembled to address technical issues related to BLM reserved water rights for the Wild and Scenic Missouri River. The working group is composed of technical personnel from the Bureau of Land Management (BLM), Bureau of Reclamation (BOR), and Montana DNRC. The group was directed to find technical solutions to outstanding issues while working within assumptions compatible with the BOR Upper Missouri River HYDROSS Model. This report details recommendations from the working group. All information contained in this report is subject to the negotiations process and negotiating team approval.

I. MONTHLY FUTURE USE AMOUNTS

Through negotiation, the BLM and State have agreed that future depletions to surface flow (post-1987) will be accounted for on a monthly basis and subtracted from the negotiated water volumes listed in the table below. These volumes include the amounts reserved through the Upper Missouri reservation process (see table). The technical working group has agreed on water volumes for future depletions, which will be subject to negotiating team approval. The volumes currently under consideration are:

Month	Acre-feet
January	104,158
February	120,512
March	124,168
April	201,710
May	236,645
June	79,086
July	88,878
August	79,565
September	39,679
October	35,318
November	56,774
December	98,081

II. CALCULATION OF MONTHLY DEPLETIONS

Depletions to surface flows will be estimated from monthly depletion coefficients developed for various types of water use. In order to monitor the cap amounts, the DNRC will calculate preliminary monthly depletions according to the type of use and subtract the amounts from the future available water. However, permanent subtractions to the cap will be finalized when a permit is perfected and verified.

In order to avoid the uncertainties of developing return flow coefficients on a basinwide scale, the group has focused on the consumptive use amounts required for each type of use, rather than trying to calculate the difference between diversion amounts, direct return flows and delayed return flows in the variety of circumstances that can occur throughout the basin. Therefore, the group has assumed that depletions will occur in the same month as the diversions.

The DNRC will use the definition in Section 85-2-342(3) MCA to determine whether a particular use is non-consumptive. In addition, groundwater uses of less than 35 gallons per minute, up to 10 acre feet per year, and surface water permits of less than 35 gallons per minute and 10 acre feet per year for domestic use will not be counted against the cap.

Following is a list of the use codes now employed by DNRC, and the recommended monthly depletion coefficients.

Category 1.
Fishery, Wildlife, Recreational and Wildlife/Waterfowl Uses:
FS Fishery
FW Fish and Wildlife
RC Recreation
WW Wildlife Waterfowl

Since the water loss resulting from these uses occurs as evaporation from small ponds, depletions from the above uses will be calculated using lake evaporation factors. The monthly evaporation factors are the same as those used in the BOR model to estimate net evaporative losses at Canyon Ferry Lake, which is located at approximately mid-basin. The losses were averaged over the period of record, 1929 through 1987. The following table lists the monthly evaporative loss in feet:

January	0.00
February	0.00
March	0.00
April	0.08
May	0.17

June	0.26
July	0.50
August	0.51
September	0.35
October	0.26
November	0.04
December	0.00

Depletions will be calculated by multiplying the above factors by reservoir surface area (acres), determined upon completion and verification of the project. Depletion amounts will be subtracted from the monthly caps.

Category 2.

Geothermal and Power Generation Uses:

GE Geothermal
PG Power Generation

The consumptive portion of geothermal and power generation uses will be determined by DNRC on a case-by-case basis, and subtracted from the monthly caps.

Category 3.

Domestic, Multiple Domestic and Municipal Uses:

DM Domestic
MC Municipal
MD Multiple Domestic

The BOR Upper Missouri Basin model used a depletion of 45% of the diversion for municipal uses, distributed monthly as follows:

		resulting depletion factor
January	3%	(.45 * .03) = .0135
February	3%	= .0135
March	6%	= .0270
April	7%	= .0315
May	10%	= .0450
June	13%	= .0585
July	18%	= .0810
August	15%	= .0675

September	11%	= .0495
October	8%	= .0360
November	3%	= .0135
December	3%	= .0135

Monthly depletions for municipal, multi-family domestic, and non-exempt domestic uses will be calculated by multiplying the issued volume by the monthly depletion factors listed above, and subtracted from the monthly caps.

Category 4.

Irrigation including Lawn and Garden over 5 acres:

IR Irrigation

LG Lawn and Garden

To derive irrigation depletion coefficients, the working group agreed to use crop consumptive use requirements calculated from Great Falls weather station data. The following are net irrigation requirements (inches) for alfalfa during the 80% exceedence year. Depletion factors will be multiplied by the number of permitted acres to determine depletions, in acre feet. Monthly depletions will be subtracted from the monthly caps.

	net irrigation requirement (inches)	depletion factor (feet per acre)
January		0.0
February		0.0
March		0.0
April		0.0
May	2.50	0.2604
June	4.47	0.4656
July	7.12	0.7417
August	5.65	0.5885
September	1.13	0.1177
October		0.0
November		0.0
December		0.0

LG Lawn and Garden: for greater than 5 acres, depletions follow those used for irrigation; permits for less than 5 acres are exempted from this process.

Supplemental irrigation water rights involve multiple water sources or points of diversion

used to irrigate the same acreage. While each water right may reflect the amount necessary to irrigate the acreage, generally only one or part of each right is actually used at any given time. The concern has been raised that subtracting supplemental water rights from the cap will result in overestimating actual consumption. In the future, supplemental water rights will be identified by the DNRC from the application, but will not be subtracted from the monthly caps.

Category 5.
Livestock Uses:
ST Stock: for stock ponds, depletions will be calculated using the monthly lake evaporation factors and subtracted from the monthly caps. Other stock uses will not be counted against the cap.

Category 6.
Commercial, Industrial, Institutional, Mining and Other Uses:
OP Other Purpose
CM Commercial
IN Industrial
IS Institutional
MN Mining

A methodology to account for depletions occurring from these uses will be discussed at the negotiating session.

III. GROUNDWATER

Groundwater uses of 35 gallons per minute or less up to 10 acre feet will not be counted against the cap. The Joint Technical Team and the Negotiating Teams have not agreed on a methodology to account for groundwater uses of greater than 35 gallons per minute and more than 10 acre feet per year. The accounting for groundwater uses will be discussed at a negotiating session.

IV. STORAGE

Future storage projects will be assigned depletions based on the lake evaporation table, in addition to the depletion coefficients developed for the specific use for which the water is stored. For example, if water is stored for irrigation use, depletions will be calculated based on both evaporative losses for the entire storage period and the crop consumptive factors listed above. The depletions will be subtracted from the month during which the

water is stored. A methodology to account for when storage depletions will be subtracted from monthly caps will be discussed at a negotiating session.

V. ADMINISTRATION

DNRC will administer the future water use cap by subtracting depletions from the monthly available water amounts, and producing an annual report by March 1st of each year describing permit activity and status of the cap.

A cooperative review process will be created allowing the BLM and DNRC to discuss depletion coefficients and depletion amounts assigned to the undefined uses (commercial, industrial, institutional and "other purposes"). BLM suggests that a Memorandum of Understanding and annual meeting to discuss the annual report might be the best means to accomplish this. This issue will be discussed at a negotiating session.

The working group recommends that late claims as defined by MCA 85-2-221 should not count against the cap, because those uses are reflected in the HYDROSS model to the extent that they have been used historically. Conversely, since abandoned claims are not reflected in the model, any application to reallocate the water associated with these claims should be subtracted from the cap.

Groundwater Addendum
to Joint Technical Working Group Report **5/22/96**

Future appropriations of groundwater will be counted against the development cap **only** if they do not qualify for exception from permit requirements under Montana law (See MCA 85-2-306: Exceptions to Permit Requirements). This exception allows the appropriation of water from a well or developed spring with a maximum appropriation of 35 gallons per minute or less, not to exceed 10 acre-feet per year without a permit. Combined appropriations from the same source from two or more wells or developed springs which exceed the 35 gallons per minute / 10 acre-feet per year limitation **do** require a permit under MCA 85-2-306 and would therefore be counted against the cap.

All groundwater applications which require a permit will be counted against the development cap, regardless of location or source aquifer. The depletion coefficient applied to groundwater applications will be determined by the purpose of use to which the water will be put (i.e. irrigation use depletion coefficients will be determined by the season of use for irrigation and the coefficients developed for irrigation). Once the total depletion amount has been calculated, the depletions will be spread in equal increments throughout the year (1/12th of the total volume subtracted from each monthly cap amount).

Storage Addendum to Joint Technical Working Group Report 7/9/96

Future storage projects will be assigned depletions based on the combined lake evaporation data and depletion coefficients for the specific purpose for which the water is stored. Two basic approaches will be followed depending on the volume of reservoir water available and the volume of water needed to satisfy the purposes.

SCENARIO 1: Reservoir Volume Greater Than Demand

Under this scenario, depletions to the cap will be calculated based on the sum of reservoir evaporation and the depletions calculated by the purpose coefficients listed in the Joint Technical Team Report. Upon determining the total depletion, the monthly depletion distribution will follow the typical fill regimen for reservoirs in this area. The following schedule is based upon historical data for six existing reservoirs (Middle Creek, Smith River, Swift, Martinsdale, Willow Creek and Ruby Reservoirs,see attachment 1). This data shows a normal fill regimen from November through June at the following rates:

Month	% of Volume added
November	7%
December	7%
January	8%
February	7%
March	10%
April	21%
May	38%
June	2%
Total	100%

This fill schedule will be applied to all future reservoirs unless the application for permit specifies a different fill regimen.

The annual evaporation amount will be calculated based on the lake evaporation schedule proposed in section II of the joint technical group report. The crop depletion amounts will be totalled based on the number of acres served by the reservoir and the use months allowed by the permit (i.e. if the permit authorizes a period of use that includes July and August, the crop depletion factors for July and August will be used to calculate the crop depletion portion of the use amount to be subtracted from the cap). The total of these two amounts, annual evaporation plus crop depletions, would equal the total depletion amount for the reservoir. This amount would then be subtracted from the cap for the months during which the reservoir would fill. Since the reservoir would likely be filled over a period of several months, the amount to be subtracted from the cap for each fill month would be based upon the fill schedule shown above.

The example below illustrates the depletion calculations for a hypothetical reservoir.

Example 1: Storage Reservoir For Irrigation Use.
In the situation where an offstream storage reservoir is developed to supply water for irrigation use, the depletion would be calculated as follows:

A 1500 acre foot reservoir with 150 surface acres is proposed for off stream storage of water for irrigation use. The requested season of use is June through September to irrigate 500 acres. The following calculation shows the depletions that would apply to the cap.

Crop depletion amounts:

Month	Depl Factor AcFt/Acre	Total Crop Depl. Ac.Ft.
June	.4656	232.80
July	.7417	370.85
August	.5885	294.25
September	.1177	58.85
Total Irrigation Use		**956.75**

Lake evaporation amounts:

Month	Evap depl factor feet/surface acre	Evaporation total acre-feet
January	0.00	0.00
February	0.00	0.00
March	0.00	0.00
April	0.08	12.00
May	0.17	25.50
June	0.26	39.00
July	0.50	75.00
August	0.51	76.50
September	0.35	52.50
October	0.26	39.00
November	0.04	6.00
December	0.00	0.00
Total evaporation loss		**325.50**

Total Consumptive use for reservoir = 1282.25

Depletion amounts to be subtracted from cap for this reservoir:

Month	% Fill	Amount subtr from cap (1282.25 * %fill)
November	7	71.21
December	8	81.38
January	7	71.21
February	7	71.21
March	10	101.72
April	21	213.62
May	38	386.56
June	2	20.34
Total		**1282.25**

SCENARIO 2: Demand Exceeds Reservoir Volume

In the case where demand exceeds supply of the reservoir, the remaining demand over and above reservoir supply will be depleted in the same manner as any direct flow water right, provided that it isn't a supplemental right.

Example 2:

A 1500 acre foot reservoir with 150 surface acres is built to supply water for 2000 acres of irrigated land. The period of use is June through September. The following example illustrates the calculation of the depletions which would be deducted from the future use cap.

Calculation of Demand

Crop depletion amounts:

Month	Depl Factor AcFt/Acre	Total Crop Depl. Ac.Ft.
June	.4656	931.20
July	.7417	1483.40
August	.5885	1177.00
September	.1177	235.40
Total Irrigation Use		**3827.00**

Lake evaporation amounts:

Month	Evap depl factor feet/surface acre	Evaporation total acre-feet
January	0.00	0.00
February	0.00	0.00
March	0.00	0.00
April	0.08	12.00
May	0.17	25.50
June	0.26	39.00
July	0.50	75.00
August	0.51	76.50
September	0.35	52.50
October	0.26	39.00
November	0.04	6.00
December	0.00	0.00
Total evaporation loss		**325.50**

Total Consumptive use = 4152.5 acre feet

Since the usable volume in the reservoir equals reservoir volume minus evaporative losses, the volume that can be supplied by the reservoir is (1500 - 325.5) **1174.5 acre feet**. This means that the remaining demand of (4152.5 - 1500) **2652.5 acre feet** must be supplied from natural flow.

Depletion amounts to be subtracted from cap for this reservoir:

Month	% Fill	Amount subtr from cap (1174.5 * %fill)
November	7	82.22
December	8	93.96
January	7	82.22
February	7	82.22
March	10	117.45
April	21	246.64
May	38	446.30
June	2	23.49
Total		**1174.50**

Depletion amounts to be subtracted from cap, due to natural flow use:

The remaining demand of 2652.5 acre feet will be supplied by natural flow and depletions will be distributed monthly. This water volume will irrigate 1386.2 acres, and depletions would be based on crop consumptive use coefficients as follows:

Month	Depl Factor AcFt/Acre	Total Crop Depl. Ac.Ft.
June	.4656	645.42
July	.7417	1028.15
August	.5885	815.78
September	.1177	163.16
Total Natural Flow Use		**2652.51**

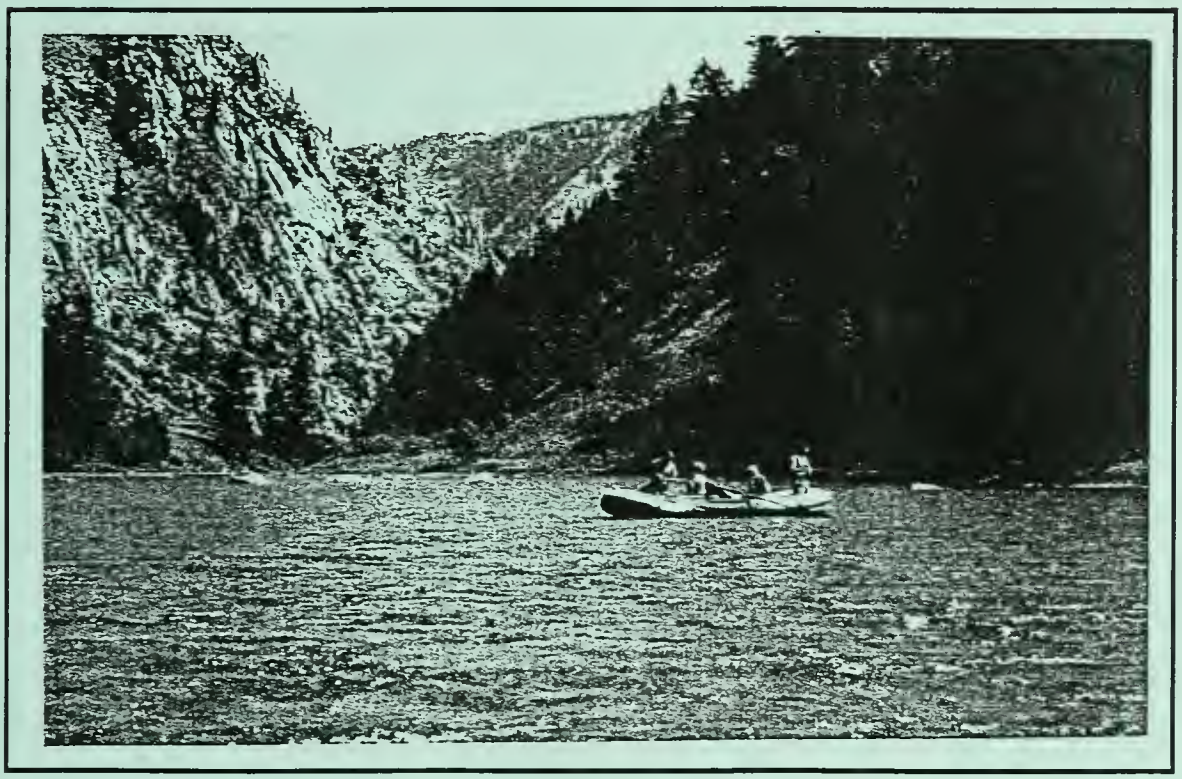
Summary of Monthly Depletions to Cap:

Month	Total Depletion (AcFt)
January	82.22
February	82.22
March	117.45
April	258.65
May	471.81
June	707.91
July	1103.15
August	892.28
September	215.66
October	39.00
November	88.22

December	93.96
Total	**4152.53**

APPENDIX D

ASSERTION OF FEDERAL RESERVED WATER RIGHT FOR INSTREAM FLOW IN THE BEAR TRAP CANYON OF THE MADISON RIVER



MAY 1994

U.S. DEPARTMENT OF INTERIOR
BUREAU OF LAND MANAGEMENT

CONTENTS

SUMMARY 1
- LOCATION 1
- UNIQUE ATTRIBUTES OF AREA 1
- SIGNIFICANT HISTORY 1
- AUTHORITY UNDER WHICH THE BLM IS ASSERTING INSTREAM FLOW RESERVED WATER RIGHTS 1

PURPOSE 2
- VISITOR USE 2
- FLOWS NECESSARY FOR FISH AND WILDLIFE 3
- FLOWS NECESSARY FOR RECREATION 3
- FLOWS NECESSARY FOR AESTHETIC REASONS 5
- FLOWS NECESSARY FOR CHANNEL MAINTENANCE 5
- POTENTIAL CONFLICTS 5
- SUMMARY 5

DETERMINATION OF AMOUNT 6
- METHODOLOGY 6

ANALYSIS OF AVAILABILITY 6

BENEFITS 8

MONITORING 8

LITERATURE CITED 9

SUMMARY

The Bureau of Land Management, United States Department of Interior is asserting a Federal Reserved Water Right for an instream flow in the Bear Trap Canyon of the Madison River. The purpose of the claimed flow will be to protect the recreational values of the area (aesthetics, fishing, floating). These flows are necessary to maintain the character of this unique area consistent with the intent of the original withdrawal as a public recreation site. The priority date of the reserved water right is the date of the withdrawal, June 9, 1971. The United States claims a minimum flow of 1,100 CFS year round to protect the purposes for which the area was reserved.

LOCATION

The Bear Trap Canyon is located in southwest Montana in Madison County where the Madison River cuts through the northwestern end of the Madison Range. An area roughly 6,000 acres adjacent to, or encompassing, the Madison River for approximately 9 miles was designated as wilderness in 1983. The canyon is about 31 miles southwest of Bozeman, Montana, just south of Montana Highway 84. Refer to Figure 1 for a location map. The reach of river for which BLM is asserting a federal reserved water right for instream flow is from T4S R1E Sec. 20 SW1/4 downstream to T3S R1E Sec. 15 NE1/4

UNIQUE ATTRIBUTES OF THE AREA

An outstanding feature and attraction of the Bear Trap Canyon is the white water floating. Floating the Bear Trap offers possibly the most exciting and challenging white water in Montana. The area also offers excellent trout fishing opportunities. The Madison River has been identified as a Class I fishery by the Montana Department of Fish, Wildlife and Parks (MDFWP) for its exemplary fishing values. Outstanding solitude and natural values attract recreationists looking for a wilderness environment for their activities.

SIGNIFICANT HISTORY

Bear Trap Canyon was withdrawn, as a public recreation site, from all forms of appropriation under public land laws, including mining laws, and from leasing under mineral leasing laws on June 9, 1971. The BLM subsequently established the Bear Trap Canyon as a primitive area on September 13, 1972. With the passage of the Federal Land Policy and Management Act (FLPMA) in 1976, it became an instant study area (ISA) subject to study for wilderness suitability. The area was recommended as suitable for wilderness in an April 1980 study submitted to the Department of Interior, the President, and Congress. On October 31, 1983, the Bear Trap Canyon was designated wilderness as one component of the 259,000-acre Lee Metcalf Wilderness (USDI 1984).

AUTHORITY UNDER WHICH THE BLM IS ASSERTING INSTREAM FLOW RESERVED WATER RIGHTS

Intent of Withdrawal for Public Recreation Site

The Bear Trap Canyon, with its recreation, aesthetics, fish and wildlife values is of distinction because of the Madison River. The Madison River is indisputably the predominant feature of the recreation area and the means of passage for many who visit there. As such, it is essential that appropriate steps be taken to protect the flows needed to sustain the recreation values and to facilitate the continued enjoyment of the area.

The withdrawal states:

By virtue of the authority vested in the President and pursuant to Executive Order No. 10355 of May 26, 1952 (17F.R. 4831), it is ordered as follows:

Subject to valid existing rights, the following described public domain lands, under the jurisdiction of the Secretary of the Interior, and national forest lands, under the jurisdiction of the Department of Agriculture, are hereby withdrawn from all forms of appropriation under the public land laws, including the mining laws (30 U.S.C., Ch. 2), and from leasing under the mineral leasing laws, and reserved for the protection of public recreation values: Dated June 1 1971. [FR Doc. 71-7988 Filed 6-8-71; 8:46am

See Appendix F for legal description of withdrawn lands.

The Federal Land Policy and Management Act of 1976 states that:

> "... the public lands be managed in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archeological values; that, where appropriate, will preserve and protect certain public lands in their natural condition; that will provide food and habitat for fish and wildlife and domestic animals; and that will provide for outdoor recreation and human occupancy and use; ...." (Sec. 102(a)(8); Public Law 94-579-October 21, 1976).

The following is a portion of the BLM Manual 7250 - Water Rights describing the BLM authority to assert a Federal Reserved Water Right for BLM activities and programs.

BLM Washington Office Policy

.12 Federal Reserved Water Rights.

A. Description. This class of water rights is a judicial creation derived from Winters v. United States, 207 U.S. 564 (1907), and subsequent Federal case law which collectively hold that when the Federal Government withdraws land from the public domain and reserves it for a specific purpose, the Federal Government, by implication, reserves only the minimum amount of water necessary which is then unappropriated to accomplish the primary purpose of the reservation. Federal reserved water rights may be claimed by the BLM where the congress has by statute withdrawn lands from the public domain for a particular Federal purpose or the President has withdrawn lands from the public domain for a particular Federal purpose, pursuant to congressional authorization.

BLM Montana State Policy

.12B Federal Reserved Water Rights. There are several types of withdrawals administered by the Bureau, and water quantities necessary to fulfill the purpose of the withdrawal are reserved by the Federal government.

PURPOSE OF THE BEAR TRAP CANYON PUBLIC RECREATION SITE

The instream flow reserved water rights claimed are necessary to fulfill the purposes for which the Bear Trap Canyon Public Recreation Site was established. Instream flows are necessary to protect the public recreation uses of the water such as aesthetics, fish and wildlife habitat, fishing, floating and general recreation.

VISITOR USE

Table 1 shows an estimate of the annual use for the most popular recreational activities in the Bear Trap Canyon.

TABLE 1. VISITOR USE

***Estimated Recreation Visits to Bear Trap Canyon - 1993**

Activity	*Total Recreation Use%*	*Visits*
Bank Fishing	48	3,240
Hiking	32	2,160
Recreational Floating	24	966
Float Fishing	6	434
Total	100	6,800

The area offers outstanding bank fishing, white water fishing, and float fishing. The BLM studies (Baty 1977 and BLM) show the area to be important as a primary destination point for local and regional residents, with increasing use by non-residents throughout the United States. Recreation use inventories indicate that about half the use of Bear Trap Canyon is by Bozeman area residents, one-quarter from the rest of Montana, and one-quarter from non-residents. Non-resident visitors annually come from all fifty states. Good fishing, hiking, and white water floating in a wild, scenic canyon environment are the chief attractions (USDI, 1984).

The above information demonstrates that without adequate instream flows, the canyon would lose it's predominant reason for people to visit the area.

FLOWS NECESSARY FOR FISH AND WILDLIFE

The Montana Department of Fish, Wildlife and Parks (MDFW&P) conducted extensive fishery studies both up and down river from Bear Trap Canyon. In 1970, the MDFWP filed for instream flows (so called "Murphy's Rights") on the Bear Trap section of the Madison under the authority of Section 89-801, Revised Codes of Montana 1947, as amended. The flows filed for were as follows:

Time Period	*Amount (cfs)*
January 1 through May 31	1,200
June 1 through December 31	1,500

DFWP studies since 1970 have compared flow regimes with electrofishing population estimates to define the flows needed to maintain the high quality trout fishery of this reach of river at the existing level. The results of these studies differ from the amounts filed for in 1970. These revised flow recommendations are shown in Table 2.

MDFW&P has negotiated with Montana Power Company to maintain a minimum flow release of 1,100 cfs from Madison Dam. This has been in effect for approximately twenty years. MDFW&P believe that these flows serve as the minimum required to maintain the fishery in the Bear Trap Canyon. (Vincent, 1994)

TABLE 2
MDFW&P FLOW RECOMMENDATIONS

Time Period	*Flow Recommendations (cfs)**
January	1,300
February	1,300
March	1,300
April	1,300
May 1-15	1,300
May 16-31	1,300
June 1-15	1,603
June 16-30	1,677
July 1-15	1,423
July 16-31	1,300
August	1,300
September	1,300
October	1,300
November	1,300
December	1,300

* Derived from trout population and flow data and the dominant discharge/channel morphology concept.

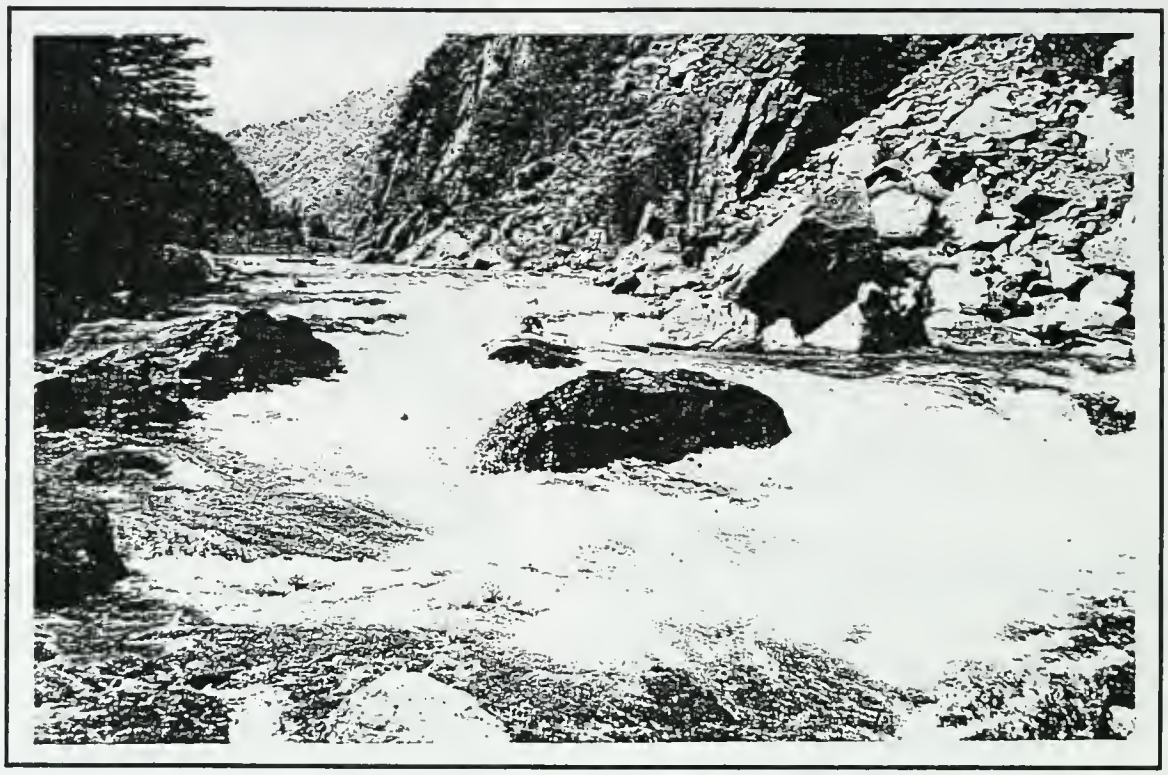
The Bear Trap Canyon has provides important winter habitat for bald eagles. In 1990, a breeding pair of bald eagles nested in the canyon and have successfully fledged young annually since that time. This breeding pair depends entirely on the Madison River corridor and the associated fishery for their food base. Maintenance of the requested instream flows which are suitable to sustain the Madison River fishery will allow the continued use of Bear Trap Canyon by bald eagles.

FLOWS NECESSARY FOR RECREATION

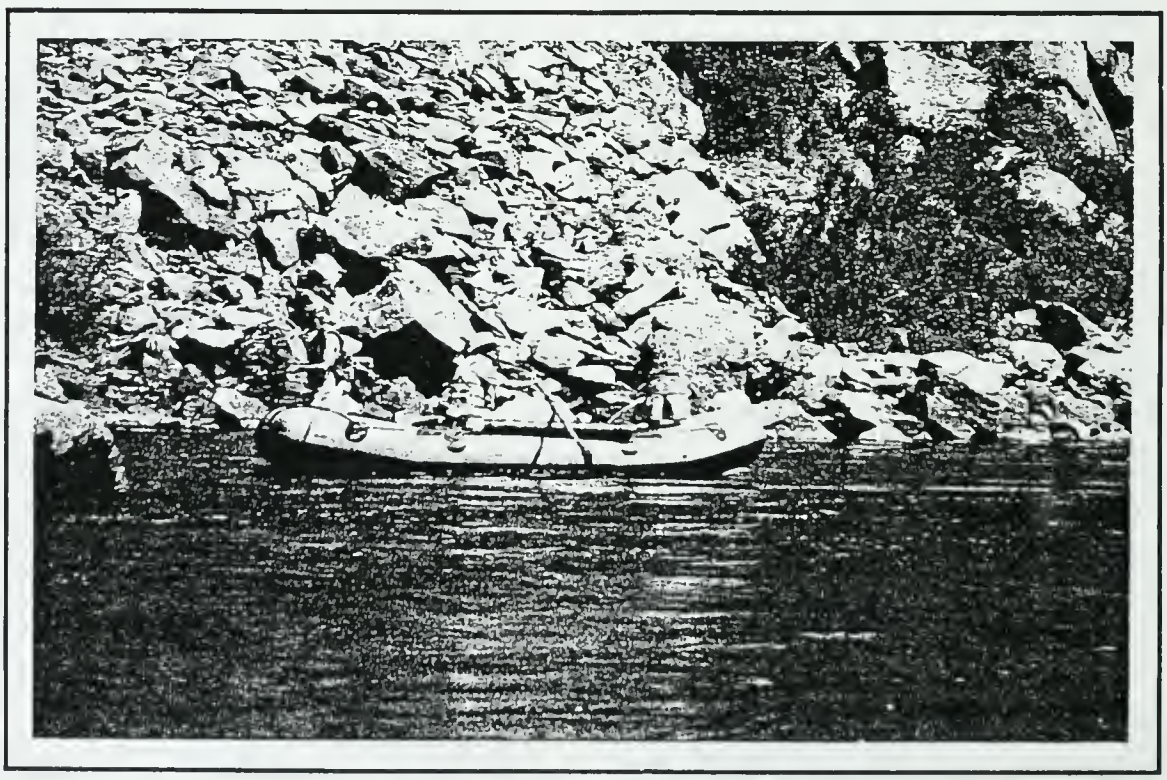
Formed by the Madison River as it cuts through the Madison Range, the Bear Trap offers raging rapids, solitude, outstanding recreational opportunities and magnificent scenery. The 1,500-foot cliffs that border the canyon serve as a scenic backdrop for wilderness activities such as white-water floating, hiking, bankside or float fishing, studying nature, and just enjoying the canyon's beauty and grandeur.

Water flowing through the Bear Trap Canyon is primarily controlled by the Montana Power Company's (MPC) Hebgen dam more than 50 miles upstream. The Madison dam at the mouth of Ennis Lake has very limited water storage capability. Flows are measured in cubic feet per second (cfs), which is the number of cubic feet of water passing a given point on the river bank in one second. Flows vary from 900 to 10,000 cfs depending on the season and on water releases from the controlling dams (Madison and Hebgen). Water flows may vary to some extent during a single day due to water releases from the Madison Dam.

Optimum flow for most floating activities is 1,700-2,200 cfs. Affidavits were sent out to four outfitters and guides that use the Bear Trap, requesting that they state the minimum flow necessary for a safe float. Two outfitters replied to the affidavits. They both stated that 1,100 cfs was the minimum flow. (Refer to Table 3) The floating season was assumed to be from May through August.



Floating Kitchen Sink Rapids in Bear Trap Canyon



Float Fishing in Bear Trap Canyon

TABLE 3
EXPERT OPINIONS ON FLOW RECOMMENDATIONS FROM PROFESSIONAL OUTFITTERS AND GUIDES AND BLM PERSONNEL

	Minimum flow (cfs)	*Optimum flow (cfs)*
1)	1,100	1,800
2)	1,100	1,500-2,500
BLM)	1,100	1,500-2,200

The opinion of the BLM Wilderness Specialist in charge of the Bear Trap area is that 1,500-2,200 cfs are needed for an optimum float. Minimum flows required are 1,100 cfs. The river can be floated at 1,100 cfs, however there are several points where rocks become a hazard and rafts run aground at this flow. (Ashor, 1993).

FLOWS NECESSARY FOR AESTHETIC REASONS

Due to the nature of the canyon (i.e., bedrock), low flows do not detract from the beauty of the canyon. The requested flows would maintain other aesthetic values such as such as wildlife viewing through the maintenance of fish and wildlife habitat.

FLOWS NECESSARY FOR CHANNEL MAINTENANCE

The river is structurally controlled by bedrock and Ennis Lake acts as a sediment retention structure, so large flushing flows are not necessary to maintain a channel capable of handling peak flows. Minimum flushing flows to scour gravels of accumulated sediments are necessary to maintain spawning habitat.

POTENTIAL CONFLICTS

A federal reserved right for instream flow could effect the amount and timing of flows through the Bear Trap. The priority date BLM is asserting of June 9, 1971 would be junior to most water rights above Ennis Lake. However there may be some water rights that are junior to this date that could be called upon to meet these instream flow requirements in low flow periods. The critical times would occur during low snowpack years. At such times in the past, Montana Power has released the negotiated flows requested by MDFWP.

The differences in total flow between what the MDFWP's original Murphy rights, MDFWP's SB 76 filing and the BLM requests are shown in Table 4.

TABLE 4
COMPARISON OF ANNUAL AMOUNTS

	Total (acre-feet)/year
Murphy's Rights	995,867
SB-76 Submission Request	926,549
BLM Request	796,363

SUMMARY

The BLM is requesting a schedule of flows equal to the minimum flows necessary to sustain fish, wildlife and recreation. Table 5 compares flows already held by MDFWP with the BLM requests and other pertinent flow values.

While the MDFWP has indicated in the past that higher flows are necessary for maintenance and enhancement of the fishery in the Bear Trap Canyon they have indicated that 1,100 CFS is a level which will minimally maintain the existing fishery in the canyon. The flows for recreation and fisheries will also provide for channel maintenance.

TABLE 5
COMPARISON OF FLOWS (cfs)

Time Period	*Original Murphy Rights*	*MDFWP SB 76 Claim*	*MDFWP Instream Flow Study Flows*	*BLM Proposed Reserved Right*	*Flows - 53 Year Record Mean-Maximim 1939 - 1992*
JANUARY	1,200	1,200	1,300	1,100	1,372 - 767
FEBRUARY	1,200	1,200	1,300	1,100	1,379 - 781
MARCH	1,200	1,200	1,300	1,100	1,428 - 891
APRIL	1,200	1,200	1,300	1,100	1,562 - 717
MAY 1-15	1,200	1,200	1,300	1,100	1,906 - 859
MAY 16-31	1,200	1,200	1,300	1,100	
JUNE 1-15	1,500	1,500	1,603	1,100	2,868 - 1,992
JUNE 16-30	1,500	1,500	1,677	1,100	
JULY 1-15	1,500	1,423	1,423	1,100	1,831 - 972
JULY 16-31	1,500	1,300	1,100	1,100	
AUGUST	1,500	1,300	1,100	1,100	1,532 - 1,044
SEPTEMBER	1,500	1,300	1,100	1,100	1,637 - 933
OCTOBER	1,500	1,300	1,100	1,100	1,944 - 810
NOVEMBER	1,500	1,300	1,100	1,100	2,001 - 961
DECEMBER	1,500	1,300	1,100	1,100	1,524 - 974

DETERMINATION OF AMOUNT

METHODOLOGY

To arrive at the flows necessary for recreation, the BLM sent letters to four outfitters and guides who used the Bear Trap Canyon portions of the Madison River and requested that they state their opinion on 1) the minimum flow necessary for a quality float and 2) what is the flow necessary for an optimum float. The BLM Dillon Resource Area Recreation Specialist was also consulted as too what constituted a minimum but safe flow.

The methodology used at arriving at the requested schedule of flows for fish was based on biological/flow relationships and dominant discharge comparisons. The work was done by the MDFWP in anticipation of their filing for claims for flows under Senate Bill-76 (SB-76). This method is used on rivers where existing biological and flow data are adequate for deriving flow recommendations for the low flow period. Electrofishing populations determinations are compared to actual discharge amounts and the dominant discharge (a single discharge equivalent in its effect to the range of discharges which govern the shape and size of the channel).

ANALYSIS OF AVAILABILITY

Streamflow data for the Bear Trap Canyon was obtained from the USGS gauging station records for the station No. 06041000 Madison River below Ennis Lake near McAllister, Montana.

Table 6 contains the percent exceedence frequency flows. Figure 3 shows the 80th percentile exceedence, monthly mean and the requested flows. The requested flows are always less than the 50 percentile flows and are less than the 80 percentile flows, except for the month of April. The 80th percentile flow is the flow that is exceeded 80 percent of the time. The requested flows are always less than the monthly mean flows.

TABLE 6
SELECTED PERCENT EXCEEDENCE LEVELS AND MONTHLY MEANS FOR THE MADISON RIVER BELOW ENNIS LAKE, NEAR MCALLISTER, MONTANA

	*Percentile (1939-1993)**			
Month	*.20*	*.50*	*.80*	*Monthly Mean* (1939-1992)*
October	2430	1900	1430	1944
November	2480	2060	1450	2001
December	1660	1530	1310	1524
January	1560	1420	1160	1372
February	1540	1370	1180	1379
March	1690	1370	1170	1428
April	2040	1330	1070	1562
May	2460	1970	1330	1906
June	3930	2850	1770	2968
July	2380	1700	1350	1831
August	1800	1540	1270	1532
September	1950	1610	1320	1637

* From USGS (1993)

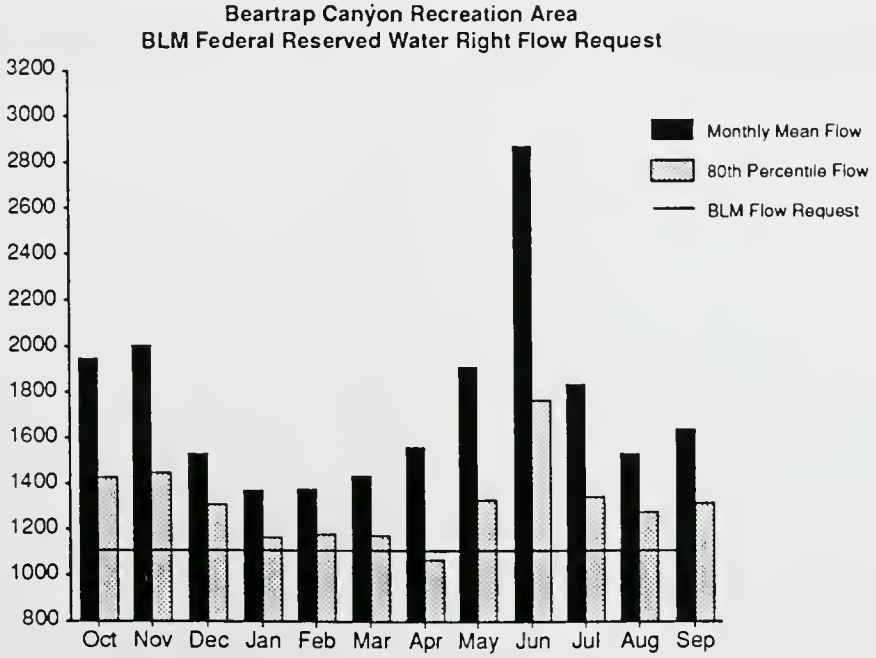
Using an average annual discharge of 1,269,276 acre feet (54 year average) and a figure of 1 cfs for 30 days = 59.5 acre-feet Table 7 shows the result of the requested flows in acre-feet/year versus the average annual discharge. This demonstrates that this federal reserved water right assertion is 63% of the average annual flow.

TABLE 7
CALCULATION OF ACRE-FEET/YEAR REQUESTED

Month	*Cfs*	*Days*	*Ac-Ft*
October	1,100	31	67,636
November	1,100	30	65,455
December	1,100	31	67,636
January	1,100	31	67,636
February	1,100	28	61,091
March	1,100	31	67,636
April	1,100	30	65,455
May	1,100	31	67,636
June	1,100	30	65,455
July	1,100	31	67,636
August	1,100	31	67,636
September	1,100	30	65,455
Totals		365	796,363
Request			964,958
Average Annual Discharge			1,269,276
% of Average Annual Discharge			63

*54 YEARS - FROM USGS (1993)

FIGURE 3
BLM FLOW REQUEST



BENEFITS

This reservation would protect the particular recreational, fish and wildlife, and scenic values that caused the area to be withdrawn from all forms of appropriation for recreational purposes.

a. It would perpetuate the fish and wildlife values at current levels.

b. It would prevent the depletion of streamflows currently enjoyed by the public for recreational purposes.

c It would help maintain the present level of water quality and thus, the "blue ribbon" status of the fishery.

d. It would ensure that low flow events do not occur more frequently than in the past.

MONITORING

The Madison River in Bear Trap Canyon has very little inflow from side drainages, The BLM proposes that USGS station number 06041000 titled "Madison River below Ennis Lake, near McAllister, Montana." be used to monitor the flows in the Bear Trap Canyon. The station is described below.

MADISON RIVER BASIN

06041000 MADISON RIVER BELOW ENNIS LAKE, NEAR MCALLISTER, MONTANA

LOCATION — Lat 45°29'25", long 111°38'00", in SW¼SE¼NW¼, section 17, T. 4 S., R. 1 E., Madison County, Hydrologic Unit 10020007, on right bank 500 feet downstream from Madison powerplant, 1.5 miles downstream from Ennis Lake, 5.7 miles northwest of McAllister, and mile 38.8.

WATER-DISCHARGE RECORDS

PERIOD OF RECORDS — October 1901 to December 1905, October 1905 to current year. Prior to October 1938 adjusted monthly runoff only, published in WSP 1309. Published as "below Madison Reservoir" 1938-49. Records published as "near Red Bluff" 1890-94 and as "near Norris" 1910 are not equivalent and are published as "near Norris" in WSP 1309.

REVISED RECORDS — WSP 1559: Drainage area.

GAGE — Water-stage recorder. Datum of gage is 4,689.03 feet National Geodetic Vertical of 1929 (levels by U.S. Army Corps of Engineers). Prior to May 7, 1941, nonrecording gage in wooden stilling well at present site at different datum. May 7, 1941, to January 13, 1945, nonrecording gages in concrete stilling well at present site and datum.

REMARKS — Water-discharge records goods. Flow regulated by Hebgen Lake (station number 06038000) and Ennis Lake (station number 06040500). Diversions for irrigation of about 23,000 acres above station.

AVERAGE DISCHARGE — 53 years, 1,748 $ft.^3/s$

Real time flows are available from the personnel at the Madison Power Plant operated by Montana Power.

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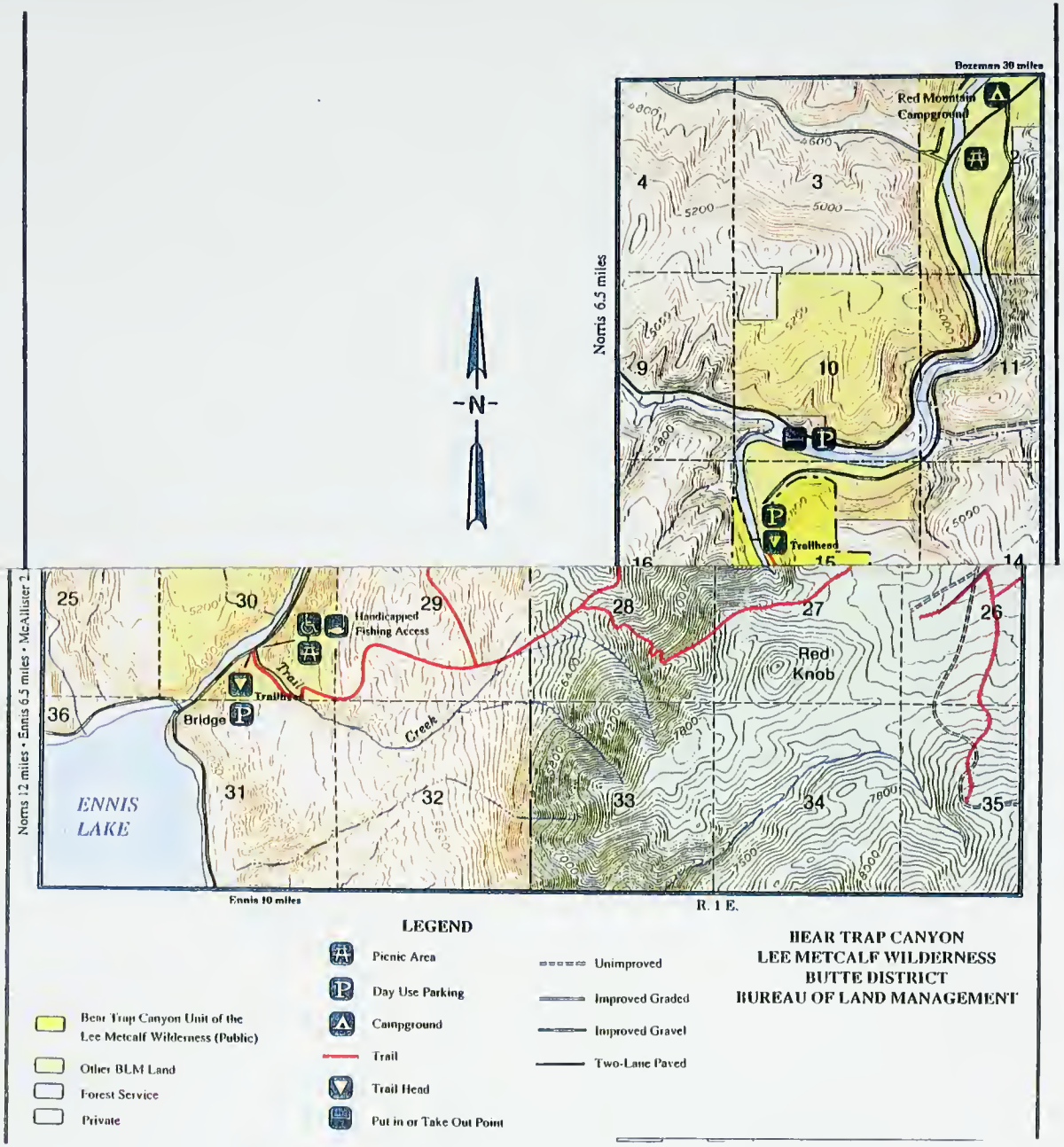
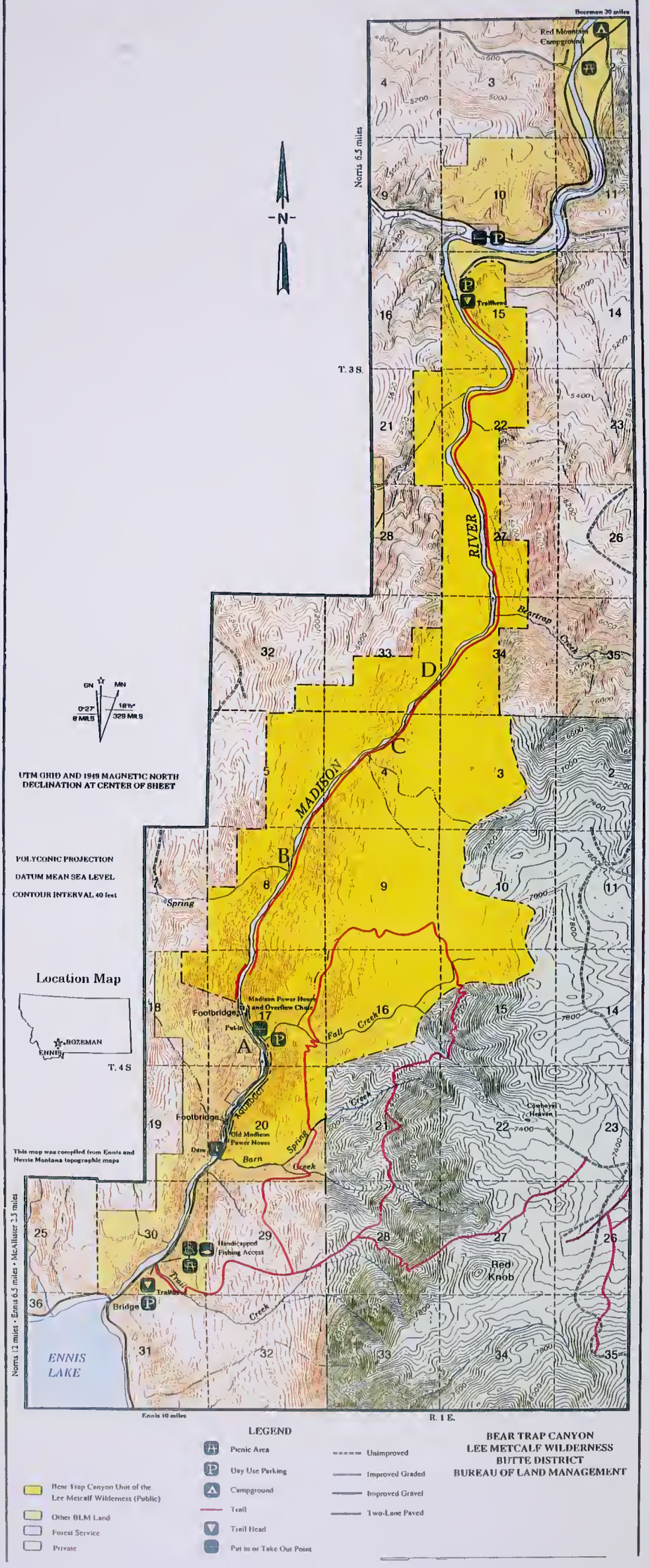

Bozeman 30 miles
Norris 6.5 miles
Red Mountain Campground
Trailhead
Handicapped Fishing Access
Trail
Trailhead
Bridge
Creek
Red Knob
ENNIS LAKE
Norris 12 miles • Ennis 6.5 miles • McAllister 2
Ennis 10 miles
R. 1 E.
LEGEND
Bear Trap Canyon Unit of the Lee Metcalf Wilderness (Public)
Other BLM Land
Forest Service
Private
Picnic Area
Day Use Parking
Campground
Trail
Trail Head
Put in or Take Out Point
Unimproved
Improved Graded
Improved Gravel
Two-Lane Paved
BEAR TRAP CANYON
LEE METCALF WILDERNESS
BUTTE DISTRICT
BUREAU OF LAND MANAGEMENT


Bozeman 30 miles
Red Mountain Campground
Norris 6.5 miles
N
T. 3 S.
Trailhead
RIVER
Bear Trap Creek
MADISON
GN
MN
0°27'
8 MILS
18½°
329 MILS
UTM GRID AND 1949 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
POLYCONIC PROJECTION
DATUM MEAN SEA LEVEL
CONTOUR INTERVAL 40 feet
Location Map
BOZEMAN
ENNIS
T. 4 S
Spring
Madison Power House and Overflow Chute
Footbridge
Put-in
Fall Creek
Old Madison Power House
Dam
Barn
Sprung Creek
Handicapped Fishing Access
Trail
Trailhead
Bridge
Cemetery Heaven
Red Knob
ENNIS LAKE
This map was compiled from Ennis and Norris Montana topographic maps
Norris 12 miles • Ennis 6.5 miles • McAllister 7.5 miles
Ennis 10 miles
R. 1 E.
LEGEND
Bear Trap Canyon Unit of the Lee Metcalf Wilderness (Public)
Other BLM Land
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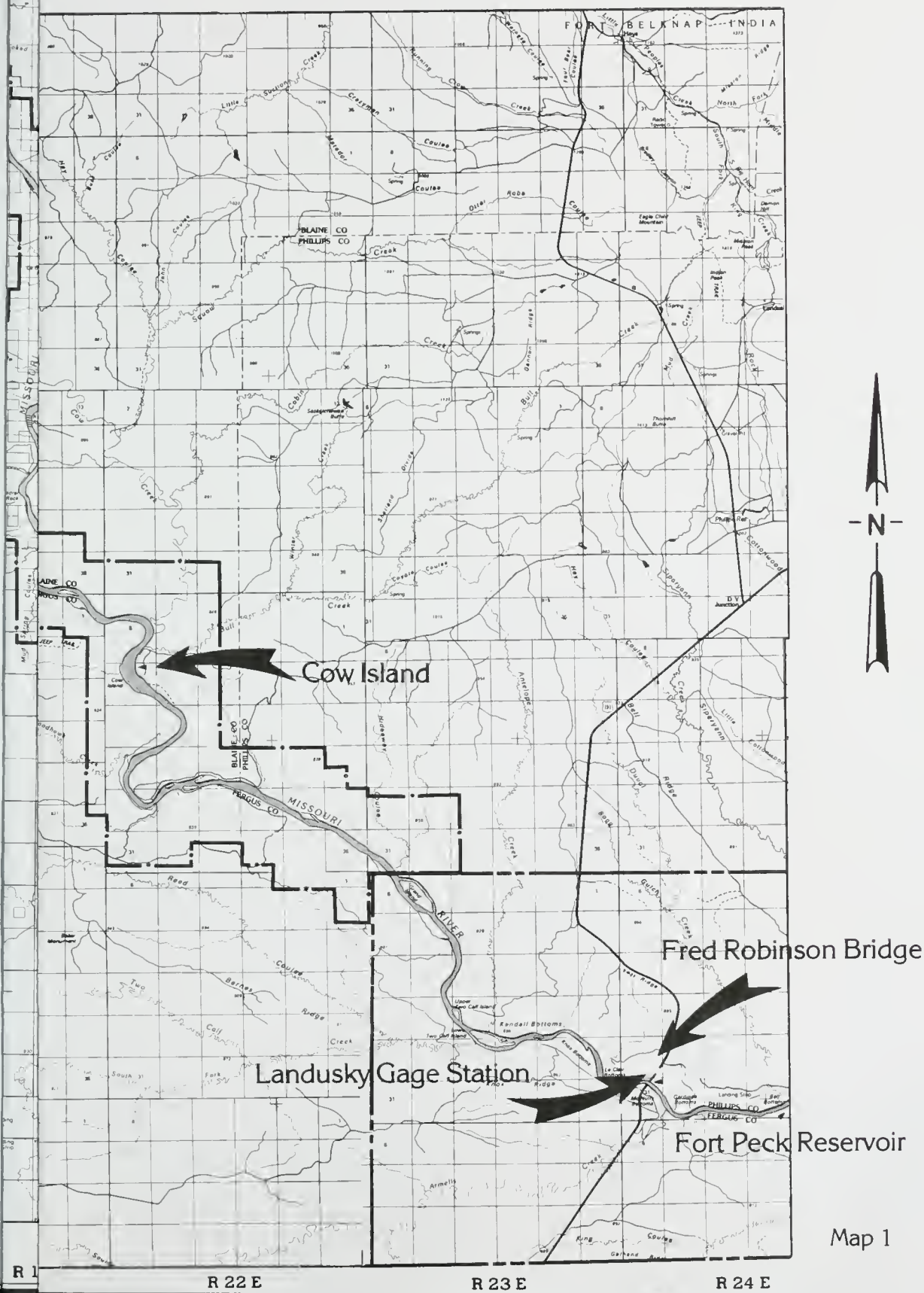
BUTTE DISTRICT
BUREAU OF LAND MANAGEMENT

APPENDIX E

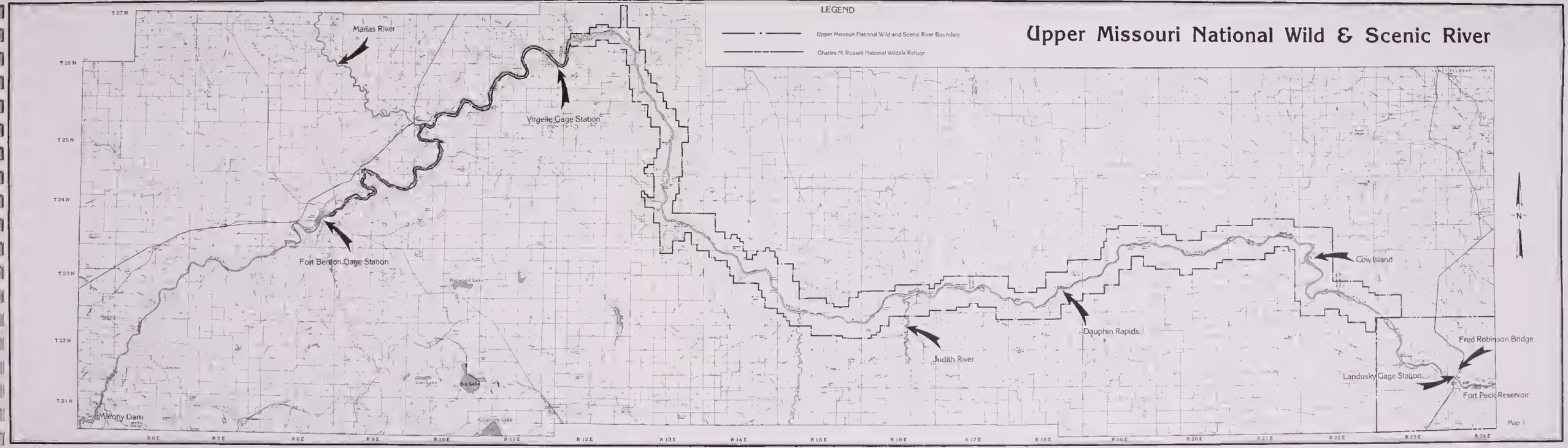
APPENDIX E

Wild & Scenic River



Map 1

Upper Missouri National Wild & Scenic River



APPENDIX F

APPENDIX F

Public Law 94-486
94th Congress

An Act

To amend the Wild and Scenic Rivers Act, and for other purposes.

Oct. 12, 1976
[S. 1506]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Wild and Scenic Rivers Act, amendments.

TITLE I—FLATHEAD, MONTANA

SEC. 101. Section 3(a) of the Wild and Scenic Rivers Act (82 Stat. 906; 16 U.S.C. 1271 et seq.) is amended by adding the following new paragraph at the end thereof: 16 USC 1274.

"(13) FLATHEAD, MONTANA.—The North Fork from the Canadian border downstream to its confluence with the Middle Fork; the Middle Fork from its headwaters to its confluence to the South Fork; and the South Fork from its origin to the Hungry Horse Reservoir, as generally depicted on the map entitled 'Proposed Flathead Wild and Scenic River Boundary Location' dated February 1976; to be administered by agencies of the Departments of the Interior and Agriculture as agreed upon by the Secretaries of such Departments or as directed by the President. Action required to be taken under subsection (b) of this section shall be taken within one year from the date of enactment of this paragraph. For the purposes of this river, there are authorized to be appropriated not more than $6,719,000 for the acquisition of lands and interests in lands. No funds authorized to be appropriated pursuant to this paragraph shall be available prior to October 1, 1977.".

Appropriation authorization.

TITLE II—MISSOURI, MONTANA

SEC. 201. Section 3(a) of the Act is further amended by adding at the end thereof the following new paragraph:

"(14) MISSOURI, MONTANA.—The segment from Fort Benton one hundred and forty-nine miles downstream to Robinson Bridge, as generally depicted on the boundary map entitled 'Missouri Breaks Freeflowing River Proposal', dated October 1975, to be administered by the Secretary of the Interior. For the purposes of this river, there are authorized to be appropriated not more than $1,800,000 for the acquisition of lands and interests in lands. No funds authorized to be appropriated pursuant to this paragraph shall be available prior to October 1, 1977.".

Appropriation authorization.

SEC. 202. After consultation with the State and local governments and the interested public, the Secretary shall, pursuant to section 3(b) of the Wild and Scenic Rivers Act and within one year of enactment of this Act—

Consultation. 16 USC 1274. note.

(1) establish detailed boundaries of the river segment designated as a component of the National Wild and Scenic Rivers System pursuant to section 1 of this Act (hereinafter referred to as the "river area"): *Provided*, That the boundaries of the portion of the river area from Fort Benton to Coal Banks Landing and the portion of the river area within the boundaries of the Charles M. Russell National Wildlife Range shall be drawn to include only the river and its bed and exclude all adjacent land except significant historic sites and such campsites and access

points as are deemed necessary by the Secretary, and to which the Secretary finds no reasonable alternative, as set forth in the management plan required pursuant to clause (2) of this section; and

16 USC 1273.

(2) determine, in accordance with the guidelines in section 2(b) of the Wild and Scenic Rivers Act, which of the three classes—wild river, scenic river, or recreation river—best fit portions of the river segment, designate such portions in such classes, and prepare a management plan for the river area in accordance with such designation.

Management.
16 USC 1274 note.

SEC. 203. (a) The Secretary of the Interior (hereinafter referred to as the "Secretary") shall manage the river area pursuant to the provisions of this Act and the Wild and Scenic Rivers Act, and in accordance with the provisions of the Taylor Grazing Act (48 Stat. 1269), as amended (43 U.S.C. 315), under principles of multiple use and sustained yield, and with any other authorities available to him for the management and conservation of natural resources and the protection and enhancement of the environment, where such Act, principles, and authorities are consistent with the purposes and provisions of this Act and the Wild and Scenic Rivers Act.

16 USC 1271 note.

Land acquisition.

(b)(1) The Secretary may acquire land and interests in land only in accordance with the provisions of this Act and the Wild and Scenic Rivers Act and the limitations contained in section 6 of that Act and only: (A) at Fort Benton for the visitor facility as provided in subsection (g)(2) of this section; (B) at the site of Fort McKenzie; (C) in that portion of the river area downstream from Fort Benton to Coal Banks Landing for historic sites, campsites, and access points in accordance with section 202 (1) of this Act; and (D) in that portion of the river area downstream from Coal Banks Landing so as to provide, wherever practicable and necessary for the purposes of this Act and the Wild and Scenic Rivers Act, rim-to-rim protection for such portion.

16 USC 1277.

Condemnation.

(2) In accordance with section 6(b) of the Wild and Scenic Rivers Act, the Secretary shall not acquire fee title to any lands by condemnation under the authority of that Act or this Act, except that the Secretary may use condemnation when necessary and within the limitations on acquisition set forth in clause (1) of this subsection to clear title, acquire scenic easements, or acquire such other easements as are reasonably necessary to give the public access to the river segment within the river area and to permit its members to traverse the length of said river area or of selected portions thereof.

Priority expenditure.

(3) The Secretary shall, to the extent feasible, give priority in expenditure of funds pursuant to this Act for the acquisition and development of campsites and historic sites, including the site of the visitor center at Fort Benton and the site of Fort McKenzie.

Easements.

(c) Consistent with the provisions of this Act and the Wild and Scenic Rivers Act, the Secretary may issue easements, licenses, or permits for rights-of-way through, over, or under the lands in Federal ownership within the river area, or for the use of such lands on such terms and conditions as are in accordance with the provisions of this Act, the Wild and Scenic Rivers Act, and other applicable law.

Bridge construction.

(d) The Secretary is authorized to permit the construction of a bridge across the river in the general vicinity of the community of Winifred, Montana, in order to accommodate the flow of north-south traffic. Such construction shall be in accordance with a plan which is mutually acceptable to the Secretary and State and local highway officials, and which is consistent with the purposes of this Act and the Wild and Scenic Rivers Act.

(e) To the extent and in a manner consistent with the purposes of the Wild and Scenic Rivers Act the Secretary shall permit such pumping facilities and associated pipelines as may be necessary to assure the continuation of an adequate supply of water from the Missouri River to the owners of lands adjacent to the river and for future agricultural use outside the river corridor. The Secretary is authorized to permit such pumping facilities and associated pipelines for use for fish, wildlife, and recreational uses outside the river corridor. Pumping facilities and associated pipelines.

(f) The Secretary shall permit hunting and fishing in the river area in accordance with applicable Federal and State laws, except that he may designate zones where, and periods when, no hunting or fishing shall be permitted for reasons of public safety or administration. Hunting and fishing.

(g)(1) The Secretary, acting through the Bureau of Land Management, shall exercise management responsibilities in the river area for:

(A) the grazing of livestock;

(B) the application of the United States mining and mineral leasing laws;

(C) the management of fish and wildlife habitat;

(D) the diversion and use of water for agricultural and domestic purposes;

(E) the acquisition of lands and interests therein;

(F) the administration of public recreational uses of, and any historic sites and campsites in, the river area; and

(G) all other management responsibilities except those set forth in paragraph (2) of this subsection.

(2) The Secretary, acting through the National Park Service, shall be responsible for the construction, operation, and management of any visitor facility in or near Fort Benton which is found necessary in accordance with the management plan developed pursuant to section 202 and the provision, at such facility, of interpretive services for the historic, archeological, scenic, natural, and fish and wildlife resources of the area. Visitor facility, construction.

TITLE III—OBED, TENNESSEE

SEC. 301. Section 3(a) of the Act is further amended by adding the following new paragraph at the end thereof: 16 USC 1274.

"(15) OBED, TENNESSEE.—The segment from the western edge of the Catoosa Wildlife Management Area to the confluence with the Emory River; Clear Creek from the Morgan County line to the confluence with the Obed River, Daddys Creek from the Morgan County line to the confluence with the Obed River; and the Emory River from the confluence with the Obed River to the Nemo bridge as generally depicted and classified on the stream classification map dated December 1973. The Secretary of the Interior shall take such action, with the participation of the State of Tennessee as is provided for under subsection (b) within one year following the date of enactment of this paragraph. The development plan required by such subsection (b) shall include cooperative agreements between the State of Tennessee acting through the Wildlife Resources Agency and the Secretary of the Interior. Lands within the Wild and Scenic River boundaries that are currently part of the Catoosa Wildlife Management Area shall continue to be owned and managed by the Tennessee Wildlife Resources Agency in such a way as to protect the wildlife resources and primitive character of the area, and without further development of roads, campsites, or associated recreational facilities unless deemed necessary by that agency for wildlife management practices. The Cooperative agreements.